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DISTRIBUTION OF STRIPED BASS FRY IN RELATION TO MAJOR WATER DIVERSIONS[1]

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For many years there has been grave concern over the possibility of damage to important California fisheries from certain water developments in the Sacramento-San Joaquin Delta. This report summarizes the results of a survey to evaluate major water diversions in relation to the California fishery for striped bass (*Roccus saxatilis*), a recreational resource which provides an estimated 2,000,000 days of angling and 1,500,000 high quality food fish to 200,000 sportsmen annually (Calhoun, 1951). Obviously, it must be protected.

The diversions in question withdraw water from the principal spawning and nursery areas of the striped bass in the Sacramento-San Joaquin Delta. The general character of this region is illustrated by the aerial photograph in Figure 1.

Quantitative information about the abundance and distribution of striped bass fry in these waters has hitherto been lacking. It is needed to estimate how many fish are endangered, what proportion of the total they represent, and what the probable eventual effects upon the striped bass population as a whole will be if they are not saved. For example, destruction of several million fingerling bass annually would be serious indeed but not disastrous if it represented only a small fraction of all those present. If, on the other hand, it amounted to a large part of the total it would be of the gravest concern for a major decline in the fishery could be expected to follow.

A lengthy series of surveys of the distribution and abundance of juvenile striped bass (Hatton, 1940; Hatton and Clark, 1942; Calhoun and Woodhull, 1948; Calhoun, Woodhull and Johnson, 1950; Erkkila et al., 1950) culminated in 1951 in the first quantitative survey, which is described in this report.

The project was a cooperative venture of the California Department of Fish and Game, the U. S. Fish and Wildlife Service and the U. S. Bureau of Reclamation. The plans for the study of the fish populations in the delta covered by this survey, including the subdivision of the area into workable tow units, the type of gear used, the technique of making hauls, the method of calculating the number of fish per division of area, the stage of tide and days on which sampling was to be carried on, and the method of presenting the data as shown in Figures 2 and 4, were made jointly by the California Department of Fish and Game and the Fish and Wildlife Service.

The Fish and Wildlife Service collected all the data in the upper part of the delta, viz., divisions 1-26 inclusive, and the California Department of Fish and Game collected all the data in the lower part of the delta, viz.,

[1] Submitted for publication February, 1953.

FIGURE 1. Aerial photograph of a portion of the San Joaquin Delta. (Obtained from Production and Marketing Administration, U. S. Department of Agriculture.)

TABLE 1 Distribution of Striped Bass Fry in 1951

Division	Water volume in million cubic feet	July 9-16		July 26-30	
		Fry in 1,000 cu. ft.	Fry in section	Fry per 1,000 cu. ft.	Fry in section
1	86	0.054	5,000	0.029	2,000
2	284	0.109	31,000	0.146	41,000
3	75	0.473	35,000	0.328	25,000
4	196	0.655	128,000	0.509	100,000
5	193	0.638	123,000	0.428	83,000
6	329	0.619	204,000	0.346	114,000
7	421	1.602	674,000	0.400	168,000
8	294	0.401	118,000	0.240	71,000
9	316	0.293	92,000	1.020	322,000
10	584	0.290	169,000	0.273	159,000
11	219	0.437	96,000	0.328	72,000
12	236	0.182	43,000	0.157	37,000

TABLE 1—Continued

Distribution of Striped Bass Fry in 1951

Division	Water volume in million cubic feet	July 9-16		July 26-30	
		Fry in 1,000 cu. ft.	Fry in section	Fry per 1,000 cu. ft.	Fry in section
13	342	0.146	50,000	0.382	131,000
14	183	0.692	127,000	0.036	7,000
15	44	0.291	13,000	0.146	6,000
16	833	0.168	140,000	0.219	182,000
17	206	0.584	120,000	0.400	82,000
18	437	0.665	291,000	0.564	246,000
19	1,481	0.771	1,142,000	0.792	1,173,000
20	2,554	1.270	3,244,000	0.942	2,406,000
21	1,590	1.182	1,879,000	0.674	1,072,000
22	541	0.036	19,000	0.168	91,000
23	310	0.600	186,000	0.036	11,000
24	322	0.073	24,000	0.045	14,000
25	201	0.036	7,000	0.032	6,000
26a	1,049	1.529	1,604,000	1.201	1,260,000
26b	1,379	1.473	2,031,000	0.109	151,000
26c	343	0.765	262,000	0.765	262,000
26d	674	1.321	892,000	0.036	24,000
26e	826	1.201	993,000	0.910	752,000
26f	456	0.401	183,000	1.311	598,000
27	530	0.144	76,000	0.766	406,000
28	617	1.226	757,000	0.331	204,000
29	617	0.696	430,000	1.898	1,172,000
30	632	0.331	209,000	0.845	534,000
31	859	0.560	481,000	3.461	2,974,000
32	818	0.990	810,000	2.371	1,939,000
33	882	1.023	902,000	0.587	518,000
34	742	0.861	639,000	0.046	34,000
35	679	0.666	452,000	0.089	60,000
36	299	4.619	1,382,000	0.551	165,000
37	560	0.807	452,000	0.420	235,000
38	701	2.412	1,692,000	0.237	166,000
39	437	1.378	603,000	0.706	309,000
40	530	2.184	1,158,000	0.408	216,000
41	602	1.818	1,094,000	0.711	428,000
42	294	2.192	644,000	1.041	306,000
43	195	14.093	2,750,000	1.077	210,000
44	188	1.005	189,000	0.235	44,000
45	141	12.997	1,838,000	0.574	81,000
46	762	0.754	575,000	0	0
47	861	0.263	226,000	0.074	64,000
48	758	0	0	0	0
49	849	0.166	141,000	0.043	37,000
50	572	0.574	328,000	0.056	32,000
51	540	0.742	400,000	0	0
52	353	0.246	87,000	0	0
53	216	1.076	232,000	0.509	110,000
54	196	0.718	141,000	0.078	15,000
55	500	1.488	745,000	0.287	144,000
56	979	0.062	61,000	0.186	182,000
57	953	0	0	0.040	38,000
58	921	0	0	0	0
59	985	0.108	106,000	0	0
60	1,062	0.024	25,000	0	0
61	473	0.144	68,000	0	0
62	739	0.159	117,000	0	0
63	932	0.045	42,000	0	0
64	621	0	0	0	0
65	368	0.123	45,000	0.117	43,000
66	710	0.461	327,000	0	0
Sherman Lake		1.579			

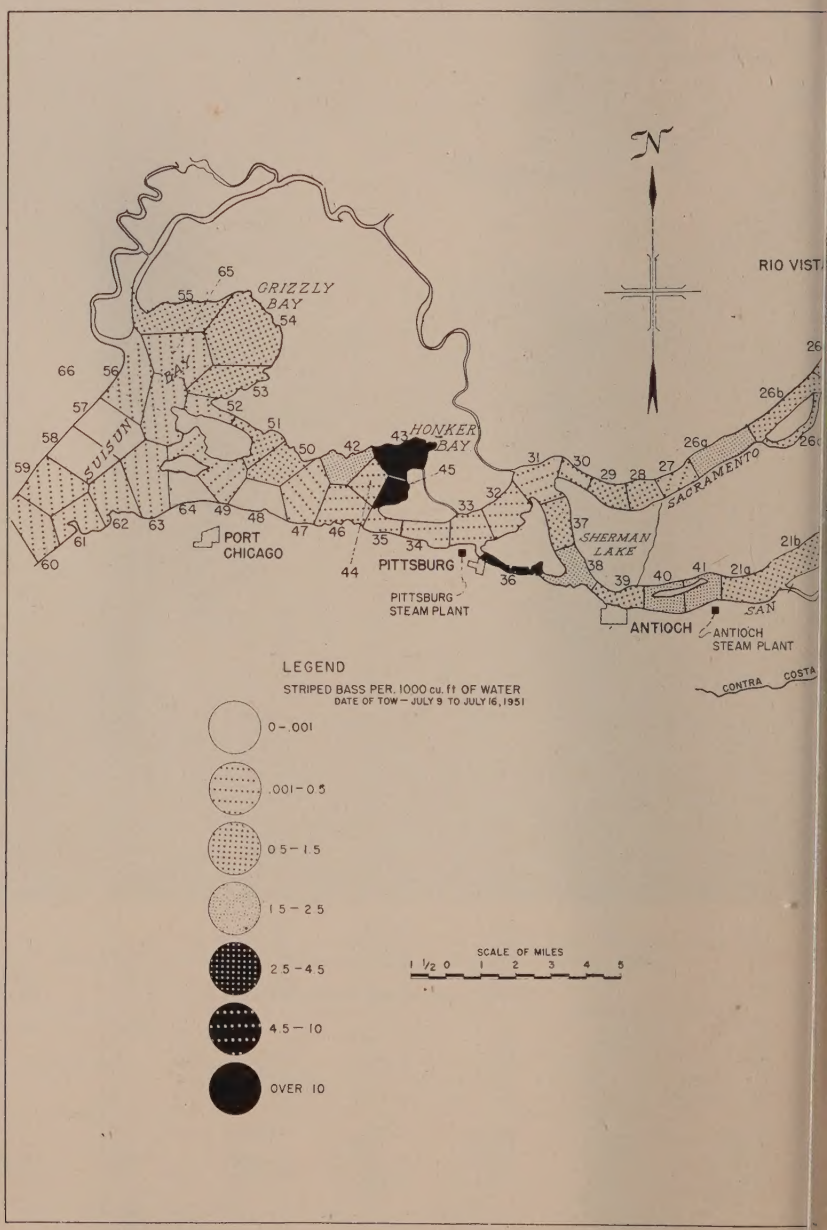
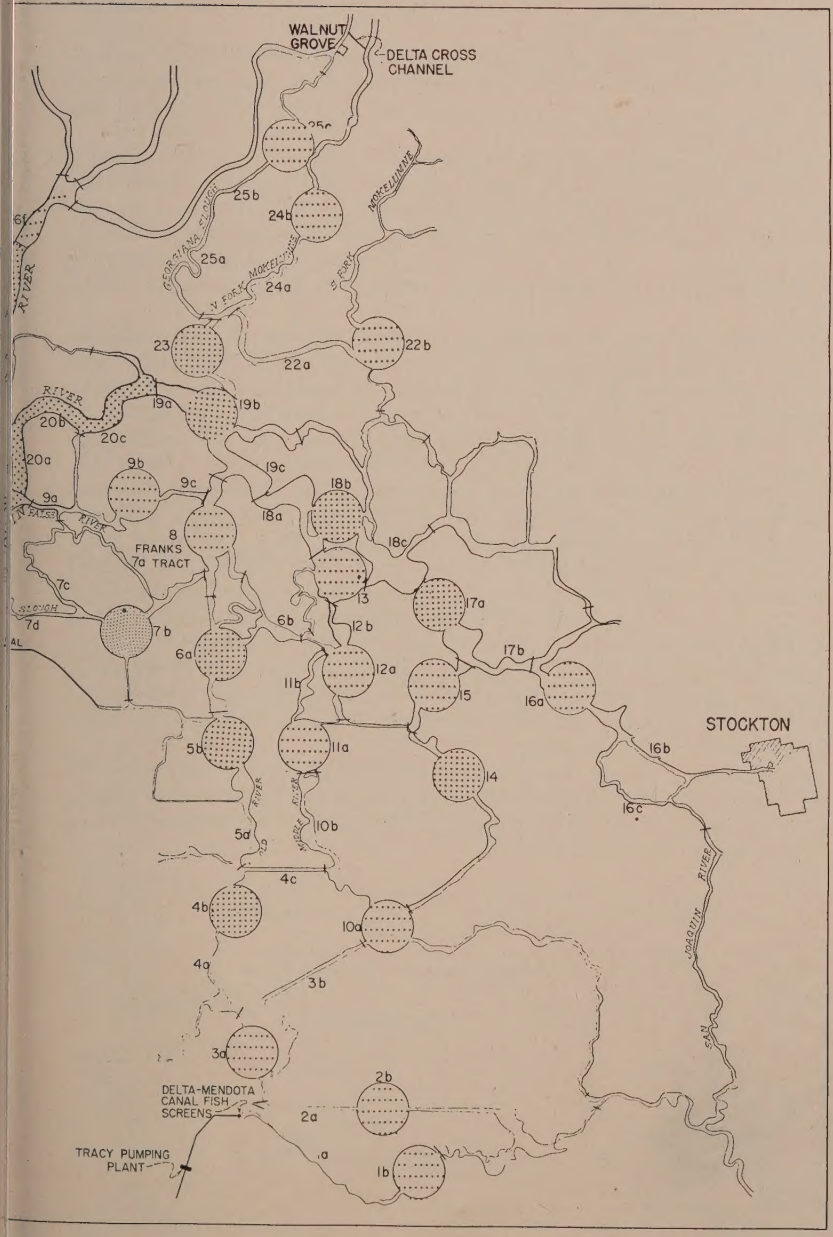


FIGURE 2. Distribution of striped bass fry during mid-July, 1951


WALNUT GROVE
DELTA CROSS CHANNEL
MOKELUMNE
MOKELUMNE
S. FORK
N. FORK
MOKELUMNE
N. FORK
RIVER
RIVER
FRANKS
7a TRACT
8
STOCKTON
MIDDLE RIVER
SAN JOAQUIN RIVER
DELTA-MENDOTA CANAL FISH SCREENS
TRACY PUMPING PLANT
25c
25b
24b
25a
24a
23
22b
22a
19a
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20c
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5a
4c
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10a
4a
3b
3a
2b
2a
1a
1b

divisions 27-66, inclusive. Each agency processed its own data to obtain the estimates shown in Table 1.

The Bureau of Reclamation provided the vessel used by the Fish and Wildlife Service together with the necessary supplies and equipment, and aided Fish and Wildlife Service personnel in other ways during the course of the survey.

This report outlines the distribution of striped bass fry during July of 1951 in relation to major delta water diversions. Other important sport and commercial fisheries are also endangered, including king salmon, shad, and catfish, as well as some less obviously important forage fishes (cf Erkkila et al., 1950). The fact that they are not included in this discussion should not be taken to minimize their importance, which is great.

Tidal currents keep the waters of the delta and Suisun Bay in almost continual motion; back and forth over great distances with each tidal cycle. For example, a float placed in the San Joaquin River near Antioch at high tide has been observed on several occasions to travel about 20 miles down the river to Martinez with a single ebb (personal communication from A. E. Morrison, U. S. Bureau of Reclamation).

Quantitative plankton sampling was accomplished under these troublesome conditions by working only during high slack tides which were followed by small ebbs, when the delta and Suisun Bay simulate a large lake for a few hours. Judging from salinity studies by the U. S. Bureau of Reclamation, the various water masses tend to maintain their individuality, and to come back into roughly the same position for a given tidal height in succeeding cycles. It was therefore possible to sample during slack tides of about the same height on several days in sequence and to combine the results; and thus, by working rapidly, to cover the major nursery grounds. In 1951 the lower of the two daily high slack tides was used in all instances.

Such sampling shows the distribution of small bass at high tide. In effect, it momentarily stops a pendulum toward the upper end of a variable swing which may attain 20 miles. This should be remembered in interpreting the data which follow.

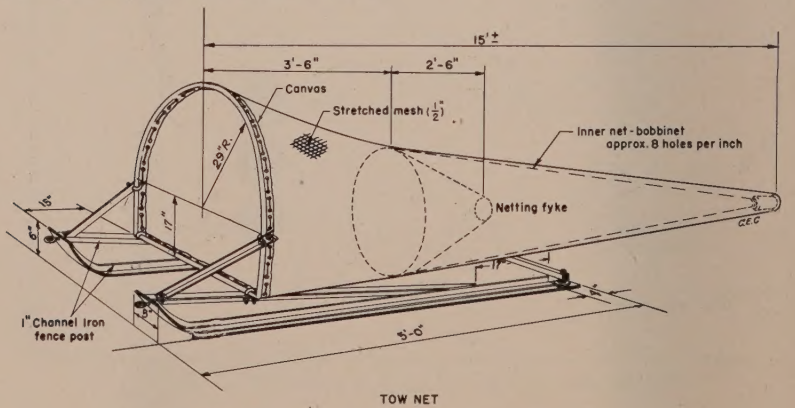


FIGURE 3. The net used to sample striped bass fry

Sampling points were distributed over the nursery grounds as evenly as the complexities of the area and as densely as the limitations of sampling time permitted. Waters surrounding each sample were bounded as shown in Figure 2, to obtain the "divisions" [2] used in estimating numbers of fry present.

The sampling net, shown in Figure 3, was mounted on skis to slide readily along soft bottoms without picking up mud. It was towed on a quarter-inch steel cable, passing from a winch amidships to an "A" frame in the stern. A boat roughly 30 feet long was used by each crew. All tows were made obliquely from the bottom to the surface, in order to sample all depths.[3]

Samples were taken only when the tide was slack or nearly so. A brief period of grace was gained by working up the river with the tide. On several days in each series the flood slack being sampled was followed by a negligible ebb. It was then possible to sample for many hours. Otherwise the task could not have been accomplished with only two boats.

The bass fry collected at each station were counted in the field and preserved for later measurement. The number caught was used to estimate the concentration within the division as a whole.[4]

For example, 48 fry were caught in Division 39 in mid-July. The net strained 34,833 cubic feet of water during this tow, giving a concentration of 1.378 fry per thousand cubic feet of water. There were an estimated 437,000,000 cubic feet of water within the division, so 603,000 fry were present, assuming the sample was representative.

The validity of the samples is discussed later.

Two complete series of tows were made in 1951 : the first in mid-July and the second toward the end of the month, at times selected because of suitable tides, as already discussed. Results are summarized in Table 1. Figures 2 and 4 show these same data plotted on a map : the heavier the stippling, the more fish, as indicated in the legend. It will be recalled that this is the flood-tide picture.

In Figure 2, showing the mid-July distribution, concentrations are low in southern Suisun Bay, but quite high in its northern and eastern portions. They are also high in the Sacramento and San Joaquin Rivers

[2] The polygons representing the divisions in Suisun Bay correspond to the Thiessen network commonly used for precipitation calculations (Linsley et al., 1949). They were drawn by erecting perpendicular bisectors on lines joining sampling stations (see also Sette and Ahlstrom, 1948). In the rivers the divisions are simply linear segments of the channel.

[3] The depth of the net at the start of each tow was calculated from the length and angle of the cable. This was checked against a sounding to be sure that the net was on or near the bottom. In deep water in Suisun Bay the net was retrieved continuously during the tow. Elsewhere it was brought up in a series of short, over-lapping steps calculated to give the desired towing period (Walford, 1938). Ten-minute tows were routine in the delta. In Suisun Bay they lasted from 6 to 19 minutes, depending upon the depth. The state team sampled Divisions 27 to 66, inclusive. A single sample was taken at the center of each of these divisions. The federal team sampled Divisions 1 to 26. They took variable numbers of samples in each division, and the average was used to obtain the division figure. Their actual sampling points were adjacent to the numerals followed by letters in Figure 2.

[4] In Divisions 27-66 the depths used to estimate volumes were the means of the soundings within the divisions when the latter were transferred to the Coast and Geodetic Charts. In Divisions 1-26, on the other hand, both areas and depths were derived from cross sectional surveys by the U. S. Army Engineers. All soundings were adjusted to conform to a high slack tide of 3.5 feet, representative of the sampling period. Divisional areas were estimated with a planimeter.

A current meter (Atlas Compass and Manufacturing Company, Vashon, Washington) was suspended in the mouth of the net by the State team during the second series of tows. The values obtained were applied to unmetered tows, using tachometer readings, to derive estimates of water volumes sampled.

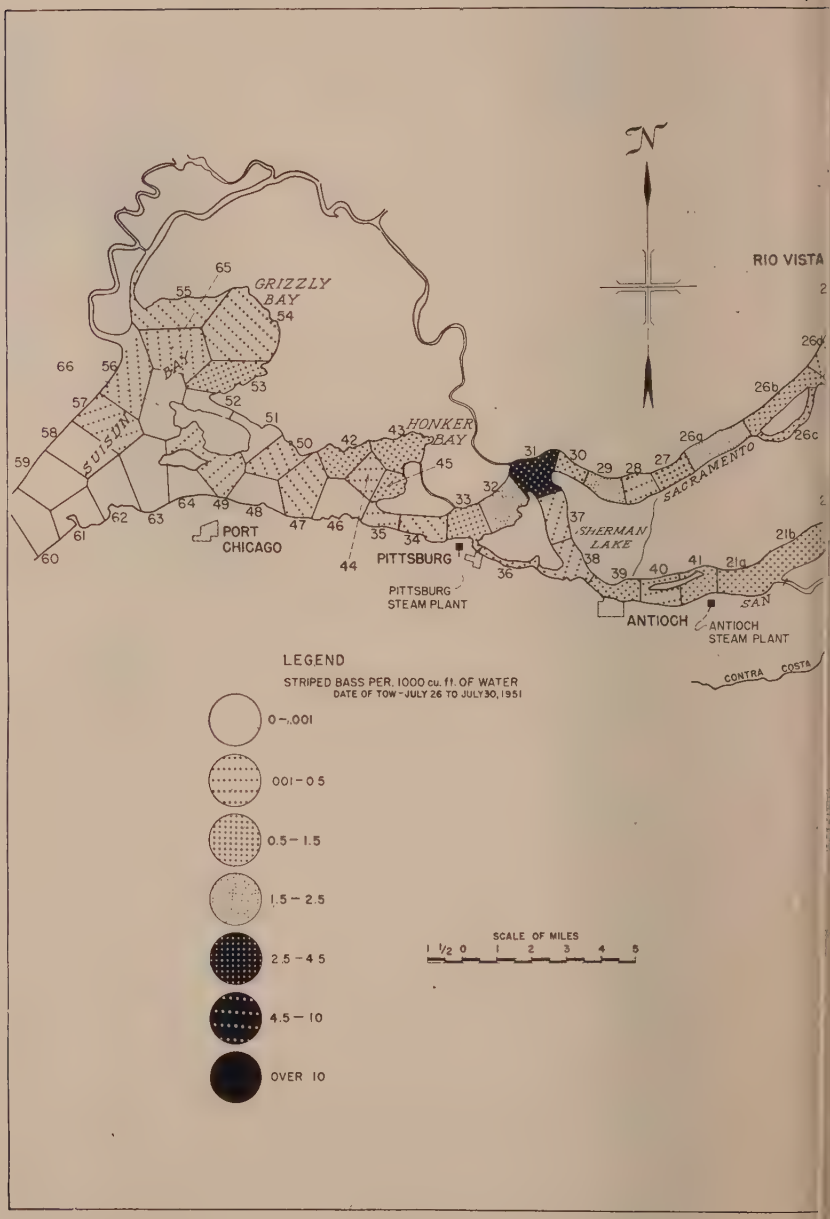
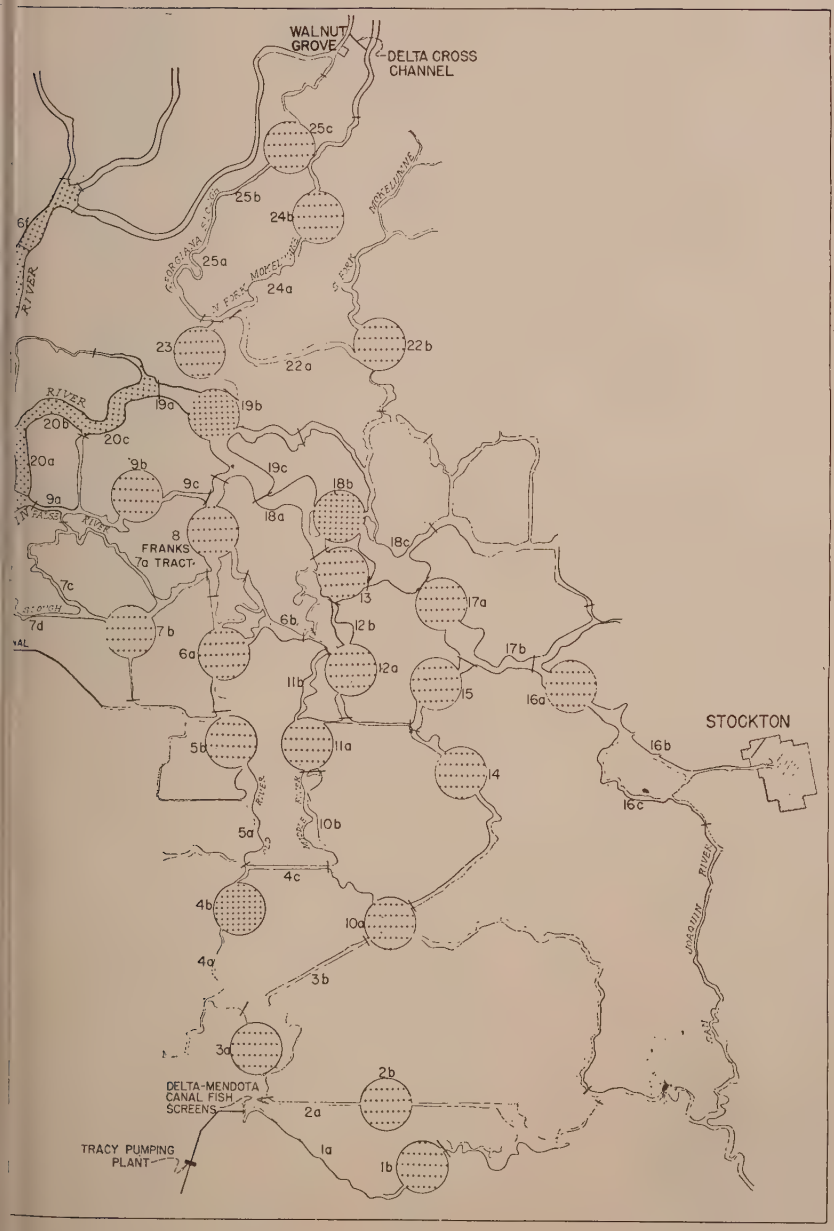


FIGURE 4. Distribution of striped bass fry during late July, 1951


WALNUT GROVE
DELTA CROSS CHANNEL
25c
25b
24b
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23
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19a
19b
20b
20c
20a
19c
9b
9c
18b
9a
18a
8
FRANKS
7a TRACT
18c
7c
13
17a
7d
7b
12b
6b
6a
17b
12a
11b
15
16a
STOCKTON
5b
11a
16b
14
16c
5a
10b
4c
4b
10a
4a
3b
3d
2b
DELTA-MENDOTA
CANAL FISH
SCREENS
2a
1a
1b
TRACY PUMPING
PLANT

near their mouths. Fry were present everywhere in the delta, but were generally less abundant in the more remote sections than in the main channels.

The second series of tows two weeks later revealed essentially similar relationships, with generally lower concentrations everywhere, as shown in Figure 4.

These data make it possible for the first time to estimate roughly the number of striped bass fry on the major nursery grounds. The mid-July series of tows gives a figure of 35,000,000. The second series gives 20,000,000 for late July.

TABLE 2

Lengths of Striped Bass Fry in 1951 Samples

	July 9-17			July 26-30		
	Number of fish	Mean length	Standard deviation	Number of fish	Mean length	Standard deviation
Old River and Middle River (Divisions 13-15, inclusive)	196	1.03	0.26	166	1.27	0.28
Central Delta (Divisions 20-26f, inclusive)	712	1.13	0.29	353	1.51	0.34
Mouth of Delta (Divisions 27-41, inclusive)	605	1.10	0.23	302	1.48	0.26
Suisun Bay (Divisions 46-66, inclusive)	204	1.20	0.18	34	1.53	0.18
Honker Bay (Divisions 42-45, inclusive)	548	1.02	0.19	76	1.50	0.25
Entire Area (All Divisions)	2,265	1.10	0.25	936	1.46	0.30

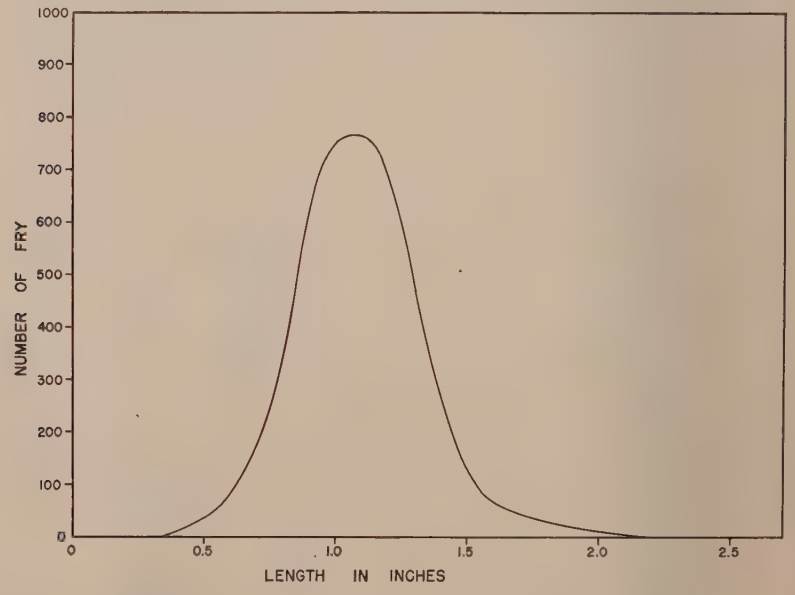

FIGURE 5. Length frequencies of all striped bass fry in mid-July samples

These estimates do not include San Pablo Bay. However, exploratory sampling there in 1951 indicated that relatively few fry were present during July. This is discussed more fully later.

The lengths of the striped bass fry taken in the two series of 1951 samples are outlined in Table 2. Individual samples were combined as indicated at the left of this table. The uniformity in the size of these fish over such wide areas is quite remarkable. The length-frequency distribution of all fish in the mid-July samples is graphed in Figure 5.

Interesting relationships between the distribution of the fry and tidal currents can be inferred from Figures 2 and 4. The flood tide, just over as sampling began, appears to have carried a mass of fish-poor water up into Suisun Bay. Waters with high concentrations of fry have been backed up into the delta. There is little doubt that these same fish-rich waters would have extended well down into Suisun Bay if sampling had followed an ebb tide.

The high concentrations in Grizzly and Honker Bays are of special interest. These shallow areas must trap fry very effectively. Relatively high concentrations were found there in 1949 and 1950 also. The extensive flats in northern San Pablo Bay may well trap the fry which pass down through the Carquinez Straits in a similar manner.

The dispersal of the developing bass down the river from the principal spawning grounds in the delta and its tributary rivers occurs rapidly. Spawning normally peaks in May, about two months before sampling was done in 1951. It centers in the delta, and is not believed to occur to any extent below Antioch.

Everything considered, the fry were surprisingly uniform in their distribution over very large areas. So were the length frequencies, already

TABLE 3

Bass Fry in San Pablo Bay

Station[1]	Date	Time		Fry	
		Started	Minutes towed	Number	Per minute
1	August 17, 1949	1145	20	3	0.15
2	August 17, 1949	1215	20	3	0.15
3	August 17, 1949	1300	20	17	0.85
4	August 17, 1949	1400	20	1	0.05
5	August 17, 1949	1530	20	0	0
1	August 1, 1950	0930	20	4	0.20
2	August 1, 1950	1000	20	7	0.35
3	August 1, 1950	1035	20	0	0
6	August 1, 1950	1110	20	6	0.30
7	August 1, 1950	1140	20	11	0.55
1	July 30, 1951	1353	23	0	0
2	July 30, 1951	1433	25	1	0.04
3	July 30, 1951	1517	23	1	0.04
8	July 30, 1951	1544	13	0	0
9	July 30, 1951	1612	13	0	0
10	July 30, 1951	1640	13	0	0
11	July 30, 1951	1738	17	0	0
12	July 30, 1951	1811	12	0	0
13	July 30, 1951	1839	12	0	0
14	July 30, 1951	1903	11	0	0

[1] Locations in Figure 6.

discussed. Tidal currents provide an obvious explanation for this rapid dispersion and uniform distribution. It seems safe to assume the ebb tides make larger transfers of fish downstream, on the average, than the flood tides return, and that the tidal currents also do a great deal of mixing.

The date when fry begin to pass down into San Pablo Bay varies somewhat from year to year, depending on the time of spawning. In 1939, for example, they reached Martinez in large numbers during the first week of August (Hatton, 1940, p. 351). In 1949 and 1950 they must have been somewhat earlier, for they were already abundant in San Pablo Bay in early August. This was shown by the samples outlined in Table 3. In 1951, on the other hand, they were apparently quite late. Exploratory sampling in San Pablo Bay on July 30th at the 10 stations shown in Figure 6 took only two fry, as shown in Table 3. This indicates that during July of 1951, when we were sampling, most of the fry were still up the river in the region surveyed. In late years, such as 1951, when the fry are slow to spread down the river, a larger proportion of the total will remain longer within reach of the diversions.

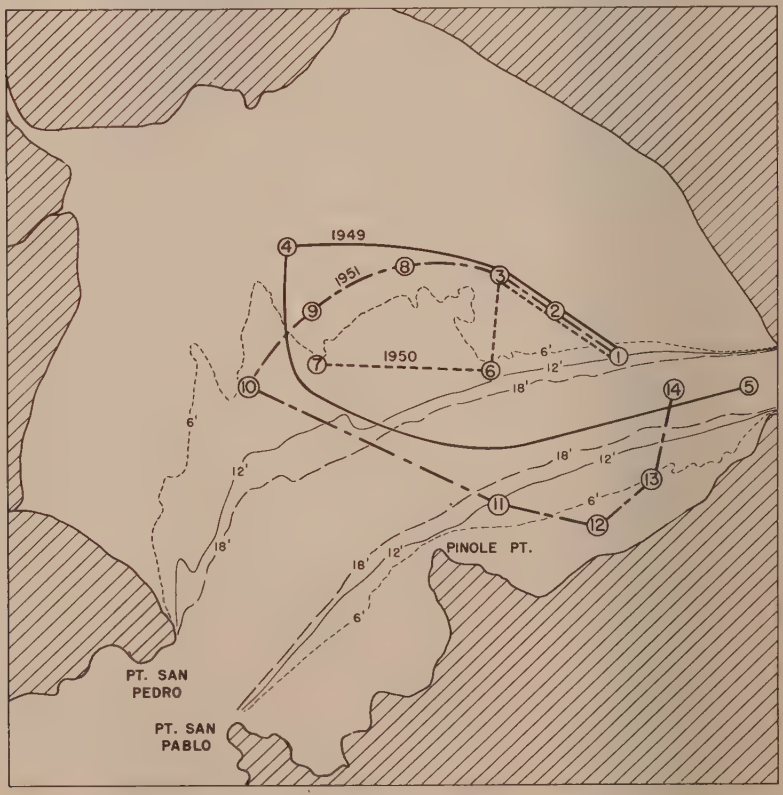

FIGURE 6. Sampling points in San Pablo Bay

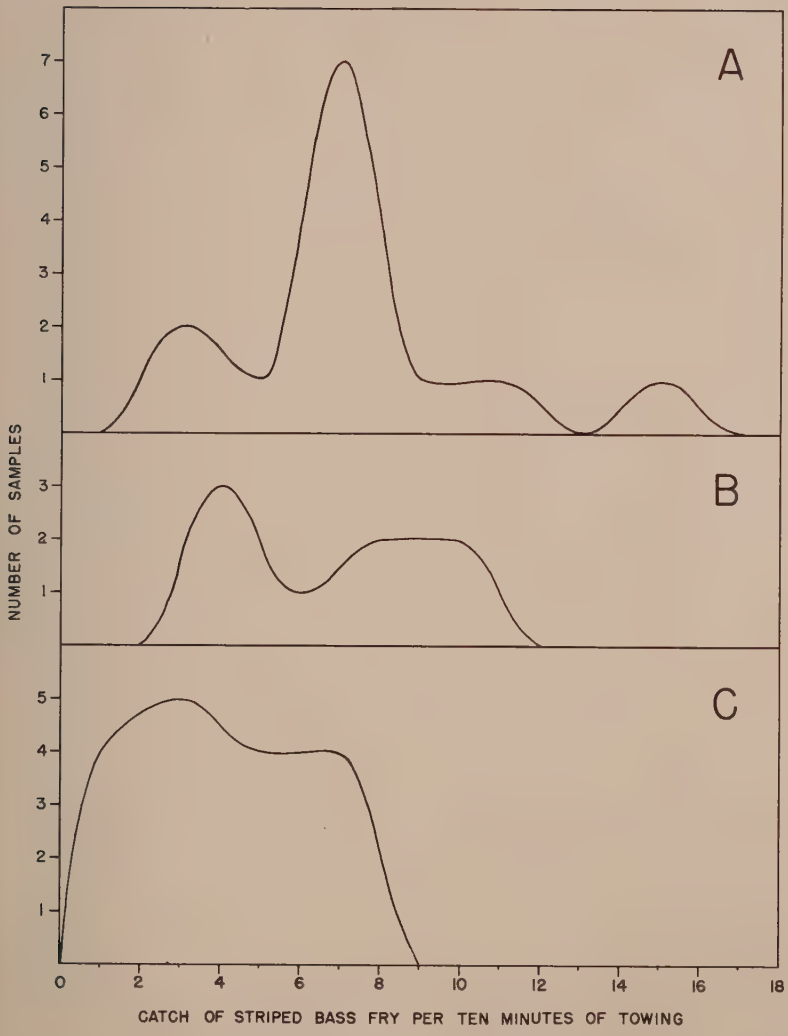

FIGURE 7. Catch frequencies of replicate tow-net samples

No bass fry have ever been taken in deep water in San Pablo Bay. This occasioned the original addition of skis to the sampling net in 1949 to explore the shallow areas, whereupon fry were taken readily. Perhaps the small bass seek out shallow areas and remain there after they have grown large enough to swim against tidal currents and control their own location.

Let us turn now to a general consideration of some of the assumptions upon which the 1951 survey was based.

One is that the individual bass fry are distributed more or less at random over broad areas. This must hold true if limited sampling is

to provide a reasonably valid representation of abundance and distribution. From all indications it does.

The general picture revealed by the 1951 survey indicates that the fry were scattered fairly uniformly over broad areas. Moreover, catch frequency curves for replicate samples tend to be reasonably "normal" with rather small ranges. The curves in Figure 7 show numbers of bass caught per tow in several series of brief, successive samples in the same place. In "a" the tide was slack, and essentially the same water mass was being sampled throughout. In "b" and "c" there was a strong tide, so the water mass being sampled was changing continually.

Highly erratic catches could have been expected if these small fish had been schooling. In that case there should have been many small or zero samples, and a few large ones when the net happened to intercept a school.

This assumption of random horizontal distribution is actually quite reasonable in view of the nearly continual tidal currents, which commonly have velocities well above the top swimming speed of an inch-long bass.

Later, however, when the small bass are several inches long, they can be observed in schools around floats and wharves in Carquinez Strait and San Pablo Bay. Our assumption applies only to a brief earlier period when the mean length is about one inch. This is when they were sampled.

A second assumption is that the net actually picks up all the fish in the column of water through which it passes. Available evidence indicates that this is also valid. The waters are turbid (Secchi disc visibility typically a foot or less) and the net cannot possibly be visible to the fish for any great distance. This is borne out by the fact that catches did not increase at night in otherwise comparable series of day and night surface tows made July 8, 1949, above Stake Point. It seems highly improbable that the fry are able to see the net and escape from it.

The towing speed was about $2\frac{1}{2}$ feet per second, while inch-long bass cannot swim much faster than one foot per second.[5] The diameter of the mouth of the net is some five feet. A small fish should therefore be aware of nothing until it is safely within the net, unless it happened to be near the rim, in which case its chance of swimming in or out should be equal. It seems improbable that lateral-line perception could enable them to avoid capture at this size.

Fish are known to stay in the net once they are caught, for replicate tows of varying durations have caught inch-long fish in numbers directly proportionate to towing time.

The projection of our 1951 tow-net samples to obtain estimates of total numbers of small fish depends on still another assumption: that spawning occurred during a relatively brief period and that most of the resulting fry were of a size to be sampled adequately by the net when the survey was made. Small fish spawned unusually late will tend to pass through the webbing and escape, while larger individuals will be better able to avoid the net than those only an inch long. In 1951 this simplification fitted the actual picture rather well, as witness the length-frequency distribution in Figure 5. In years when periodic chilling of the delta by storms interrupts and extends spawning, estimates will tend to be too small.

[5] This is known from swimming speed studies at the Contra Costa Steam Plant.

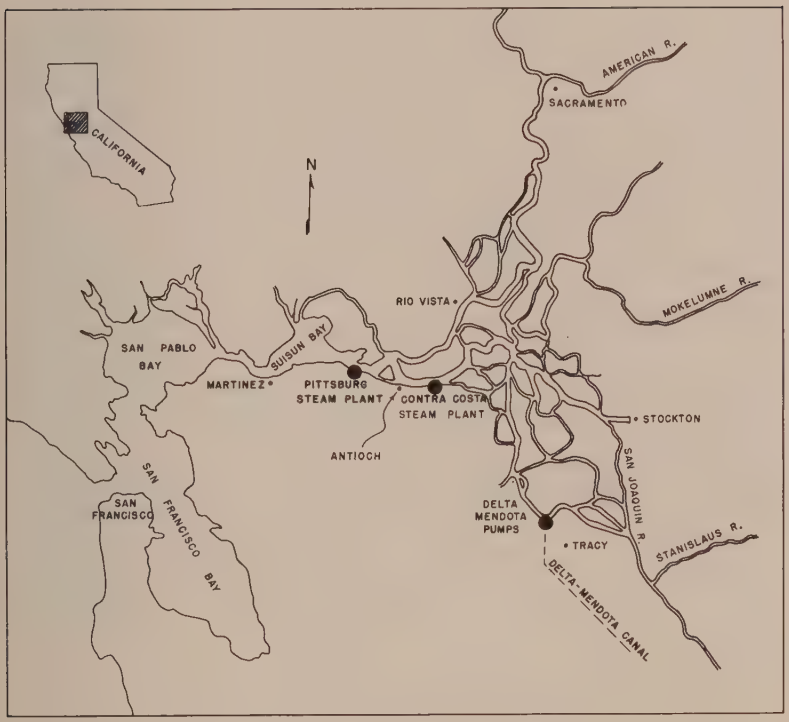

FIGURE 8. Locations of major delta diversions

An attempt to integrate the 1951 results with those from the preceding four years failed because of differences in sampling methods. Prior to 1951 only surface tows were made and sampling was restricted to the top five feet. Moreover, samples in previous years were taken without regard to the stage of the tide.

It is of particular interest, nevertheless, that the qualitative surveys made over this same area each year since 1947 have demonstrated a generally similar distribution and abundance of bass fry each year, much like that found in 1951. It is therefore possible to use the 1951 estimates with considerable confidence in evaluating diversion problems in a general way. As already mentioned, the fish appear to have been slow is spreading down the river in 1951, and the threat of the diversions will, if anything, tend to appear greater from 1951 data than if an average of several years had been available.

In conclusion, let us appraise the major delta diversions in the light of the 1951 survey. They include the Tracy Pumping Plant, the Contra Costa (Antioch) Steam Plant and the Pittsburg Steam Plant, located as shown in Figure 8.

The Tracy Pumping Plant is the "heart" of the great California Central Valleys Project. It will eventually pump 4,600 cubic feet of water per second from Old River near Tracy 200 feet up into the Delta-Mendota

FIGURE 9. Temporary intake canal and screen structure for the Tracy Pumping Plant. Photograph by U. S. Bureau of Reclamation.

Canal; thence to flow 120 miles south by gravity for irrigation of the arid San Joaquin Valley. On its journey to the pumps this water passes across the Sacramento-San Joaquin Delta, carrying young striped bass and other small fishes toward the diversion.

Water was first diverted at Tracy to a limited extent during the summer of 1951. Many small fish were sucked in from the delta and destroyed.

The present temporary intake canal and screen structure, shown in Figure 9, are being used for special studies aimed at minimizing fish losses at the final installation.

An even larger diversion is planned for the Feather River Project (California State Water Resources Board, 1951). Water from the Feather River will flow down the Sacramento River and across the delta to the point of diversion, also near Tracy. This project is in the planning stage.

Location of the Tracy and Feather River diversions so close together is unfortunate, for the drift of small fish across the delta to the pumps may go up out of all proportion to the actual increase in the amount of water withdrawn.

In addition to these irrigation projects, two large new power diversions are also entering the picture. The Contra Costa (Antioch) Steam Plant began to operate in 1951. It pumps approximately 1,000 cubic feet of water per second out of the San Joaquin River near Antioch, to cool steam condensers. A second plant is being built near Pittsburg.

The nursery grounds have been divided into three regions in the analysis in Table 4. The relative numbers of fry present in each are of special interest in relation to the diversions.

FIGURE 10. Intake structure for the Contra Costa Steam Plant. Photograph by Pacific Gas and Electric Company.

The waters of Region 1, encompassing the upper delta (divisions 1-19 and 22-25 inclusive), will be drawn upon to some extent by all four diversions. The influence of the Tracy and Feather River pumps will probably not extend much farther down, because our data represent the high-tide picture. Some of the waters which were in Region 1 during our sampling will of course travel down the river past the steam plants with the ebb and return again with the flood.

The average concentration in Region 1 was roughly one fry in each 2,000 cubic feet of water. The total number present is estimated at about 4,000,000 in mid-July, decreasing to about 3,000,000 later in the month. It is heartening that this represents no more than 10 to 15 percent of the fry in all the areas sampled. It can be concluded that a majority was already beyond the reach of the Tracy Pumps by July of 1951.[6]

Our Region 2 includes the lower delta, from the mouth of the Sacramento River (Division 35) to the western boundary of Region 1, already described. Its waters center around the intakes of the two steam plants

[6] This analysis does not include the large flooded areas in the delta known as Franks Tract, Sherman Lake, and Big Break. Two mid-July samples in Sherman Lake gave a concentration of 1.579 fry per 1,000 cubic feet. This approached closely the average figure for Region 2, which surrounds it. At mean high tide there are roughly 330 million cubic feet of water in this lake. There must therefore have been about 500,000 fry present. This is only 2 percent of all those in Region 2. Similarly, Franks Tract contains 730 million cubic feet of water at mean high tide. Assuming the same concentration as in Region 1 as a whole, there would have been roughly 350,000 fry present, or only 9 percent of those in the region. Omission of these delta lakes is therefore believed not to have affected the over-all picture of regional distribution greatly.

TABLE 4

Regional Distribution of Bass Fry in 1951

	Total water volume (million cubic feet)	July 9-16			July 26-30			Decrease	
		Number present	Percent of total	Number per 1,000 cubic ft.	Number present	Percent of total	Number per 1,000 cubic ft.	Number	Percent
Region 1 (Upper Delta Divisions 1-19 and 22-25)	8,133	3,837,000	10.9	0.47	3,143,000	15.5	0.39	694,000	18.1
Region 2 (Lower Delta Divisions 20-21 and 26a-41)	18,376	22,225,000	63.2	1.21	15,885,000	78.1	0.86	6,340,000	28.5
Region 3 (Suisun Bay Divisions 42-66)	15,168	9,087,000	25.9	0.60	1,306,000	6.4	0.09	7,781,000	85.6
	41,677	35,149,000	100	----------	20,334,000	100			

at high tide. Average concentrations were in the order of one fry per 1,000 cubic feet of water, roughly twice those in Region 1. An estimated 22,000,000 were present in mid-July.

Region 3 includes all of Suisun Bay. It is beyond the influence of the diversions. An estimated 9,000,000 fry were present in mid-July, at an average concentration of 0.6 fry per 1,000 cubic feet of water. This represented 26 percent of the total in all areas.

Two weeks later concentrations had dropped to 0.09, and only one million fry remained in Suisun Bay. Most of the decrease is believed to represent permanent transfer down into San Pablo Bay. However, increased ability to escape the net because of clearer water and larger size cannot be ruled out as contributing factors.

While it is impossible to predict exactly how many fry might be destroyed by all four diversions together, results of the 1951 survey suggest that, without protection of any sort, losses during the month when the fry are about an inch long might conceivably reach 25 percent of all those present. This would include a large proportion of the fry in the upper delta, which would be in danger from all four installations, plus an additional large number of those at the mouth of the delta which would come into the steam plants.

A hypothetical example based on 1951 concentrations will illustrate the seriousness of the steam plants. Let us assume both had been operating at their ultimate combined intake of about 3,000 cubic feet per second and without special protective measures for fish. With average concentrations of one fry per thousand cubic feet, the rate of loss could have been on the order of three fish per second, adding up to 8,000,000 for July alone.

It is quite clear that such losses cannot be condoned for even part of the year. Fortunately, the Pacific Gas and Electric Company has accepted their responsibility for protecting fish, and has already made great progress toward solution of the difficult technical problems involved. There is every reason to hope that losses of fish an inch or more long will eventually be reduced to insignificance. Most of those coming into the Contra Costa Steam Plant are already being saved. The new Pittsburg Plant, still under construction, was redesigned with a view to virtual elimination of the fish problem, on the basis of information gathered at the Contra Costa installation.

It is still too early to evaluate the situation at the Tracy Pumping Plant with any certainty.

However, progress is being made there also, and it is reasonable to expect that a situation resolved so effectively by the Pacific Gas and Electric Company at the steam plants will be handled adequately by the U. S. Bureau of Reclamation at the Tracy Pumping Plant.

There seems to be no possibility of saving bass less than an inch long, because they are too delicate to be screened. Tremendous numbers are fortunately present at this early stage. The losses which occur at the diversions will probably not be large in relation to total natural mortality.

It is also encouraging that temperature tolerance experiments at the Contra Costa Steam Plant indicate that most of these very small stripers which pass through the screens will probably survive the trip through the plant and return to the river unharmed.

As the young bass increase in size, their swimming speed increases. Soon they are no longer helpless victims of low-velocity currents, and they can avoid being sucked into diversions, or are able to swim away from the screens if they do reach them. Yearling and older bass are therefore in much less danger than the fish of the year, which have received the principal consideration in this analysis.

SUMMARY

Large, new water diversions from striped bass nursery grounds threaten the California bass fishery. They include the Tracy Pumping Plant, the Feather River Project diversion, the Contra Costa Steam Plant and the Pittsburg Steam Plant, all in the Sacramento-San Joaquin Delta. The purpose of this study was to determine the numbers of bass fry present in 1951 and their distribution in relation to the diversions.

Sampling was done during July, when fry were about one inch long. They are rather uniformly distributed over broad areas at that stage. A tow-net was hauled obliquely from bottom to surface at each station, and concentrations of fry were applied to surrounding water masses to estimate the number present. Sampling was carried on at high tide on successive days, during slack water, to stabilize the situation with respect to tidal currents. Results therefore portray the high-tide distribution.

An estimated 35,000,000 inch-long fry were present in the Sacramento-San Joaquin Delta and Suisun Bay in mid-July of 1951. About 10 percent of these were in the upper Delta, in waters within the zone of influence of the Tracy Pumping Plant. Concentrations there averaged about one fry per 2,000 cubic feet of water. About 65 percent were in the lower Delta, in waters centering around the steam plants, at concentrations of about one fish per 1,000 cubic feet of water. The remaining 25 percent were in Suisun Bay, beyond the influence of the diversions, at concentrations of about one fish per 2,000 cubic feet.

Exploratory sampling in San Pablo Bay indicated that few fry had reached there by July 20 of 1951.

The size of the bass fry was remarkably uniform throughout the area surveyed. In mid-July of 1951 the mean length was 1.1 inches.

The relationships between the distribution of the fry and tidal currents are discussed in the light of the 1951 survey.

It is concluded that all the diversions together might ultimately destroy as many as 25 percent of the fish of the year during the month when they are about an inch long, in the absence of protective measures. As the size of the fish increases and they disperse more widely, losses would presumably continue at a declining rate. Such losses cannot be condoned, and it is fortunate that methods are being evolved for rescuing the small fish which come to these diversions and returning them to safety.

ACKNOWLEDGMENTS

I am particularly grateful to netman Vincent Catania for assistance in planning and conducting the field activities in connection with the phase of the survey carried on by the California Department of Fish and Game. His knowledge of the area and his suggestions about gear

and operating methods proved invaluable. Mr. Richard Haley helped with the sampling and together with Mr. William Rowley and Mr. William C. Johnson assisted in processing samples and data.

Recognition is due the Fish and Wildlife Service for its part in the planning and carrying on of the survey and in making its data available for use in this report. Particular thanks are extended to Mr. Zell E. Parkhurst, Mr. D. W. Bates and Mr. George O. Black.

Mr. A. E. Morrison of the U. S. Bureau of Reclamation was the source of some particularly helpful ideas in the planning stage of the project, including sampling at high-slack tide. Mr. Verne T. Johnson assisted in both the field work and compilation of data.

The U. S. Corps of Engineers provided much of the depth data used in measuring water volumes.

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FOOD HABITS OF THE COYOTE IN CALIFORNIA[1]

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This study was initiated by the Department of Fish and Game in 1941 to determine the food habits of the coyote, *Canis latrans*, in California. The results, incorporated in this report, revealed the coyote to be a varied eater. Rodents were the most important source of food and, together with rabbits, made up nearly half of the total volume of prey consumed. Other important items in the diet were remains of domestic livestock and deer. Miscellaneous items including insects, reptiles, carnivores, insectivores, and unidentified materials were taken in varying amounts. Birds contributed less than 5 percent of the total food and much of this was other than game species. Plant foods were of least importance to the coyote's fare. California coyotes were found to be 96 percent carnivorous and 4 percent herbivorous. In all, some 3,982 stomachs were collected and analyzed, of which 2,222 contained food.

INTRODUCTION

The subject of predator-prey relationship is one of the most controversial problems in wildlife management. A study of the history of predator control reveals an evolution of opinion on predator-prey relationships influenced mainly by personal opinions and public sentiment. Many of the early scarcities in game populations, due principally to overshooting and to environmental changes, were attributed to predation in which the coyote was supposed to have played a major role. In addition, the notoriety of the coyote as a detriment to the livestock industry —particularly sheep and poultry raising—has been a prominent factor in bringing about an extensive predator control program. This program has been put into effect by several agencies of local, state and federal governments.

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Several notable studies have been made of the food habits of the coyote These were carried out in an effort to arrive at a better understanding of the role of the coyote in relation to his environment. Sperry (1941) reported on the laboratory examination of 8,339 coyote stomachs containing food collected over a five-year period from an area largely covering the present coyote ranges throughout the United States. Adolph Murie (1940) made a 14-month ecological study of the coyote in Yellowstone National Park, combining field observations with the examination of 5,086 coyote droppings. Olaus Murie (1935) published the results of a study of the food habits of the coyote in Jackson Hole, Wyoming, and Henderson (1930) summarized the findings of field examinations of approximately 50,000 stomachs by the Biological Survey trappers. In California, Dixon (1925) reported on food of predatory animals as revealed by stomach analyses. McLean (1934) made a study of coyotes on California game refuges and Bond (1939) published a food habits study on coyotes of the Lava Beds National Monument range in Modoc County.

ACKNOWLEDGMENTS

Included in this study are the results of 275 coyote stomach analyses made available through the courtesy of the United States Fish and Wildlife Service. Several workers have contributed to the project over the past 11 years. Mr. John Chattin assumed leadership of the project for a short time in 1946 and contributed a number of the analyses. Credit is due also to Mr. Rollo Darby, a graduate student in vertebrate zoology at the University of California, who analyzed the stomachs from the Sierra Region as material for a master's thesis. Also, the staff of the Museum of Vertebrate Zoology of the University of California aided in making the identifications of items, and readily offered the facilities of the museum to the Food Habits Laboratory. The Food Habits Laboratory staff is deeply appreciative of the excellent cooperation afforded by the hunters and trappers of our own Department of Fish and Game and of the United States Fish and Wildlife Service, who went to the extra labor and inconvenience of collecting, labeling, and preserving the stomachs for laboratory analyses.

TECHNIQUE

The stomachs were collected from trapped and shot coyotes by state and federal trappers in connection with their regular predator control activities. The stomachs were removed and placed in a 10 percent formalin solution for shipment to the laboratory. Attached to each stomach was a waterproof tag on which was noted the date and locality of capture, bait used, the sex and age of the animal and the name of the collector. Upon receipt of the stomachs by the laboratory, they were systematically catalogued for future analyses.

Equipment used in the analyses consisted principally of a dissecting microscope for separation and identification of food items. When necessary, a compound microscope was used for the identification of feathers and hair. Reference materials such as scientific skins and skeletal remains of both birds and mammals, and reptile specimens were available at the Museum of Vertebrate Zoology of the University of California. The Food Habits Laboratory made an extensive reference collection of known

samples of mammal hair and bird feathers which were mounted on microscope slides in balsam for use with the compound microscope.

The procedure for analysis was as follows: The examiner opened the stomach and squeezed the contents of its excess moisture. The remaining mass was measured in a graduate cylinder by means of water displacement technic, and the results recorded in cubic centimeters. Each stomach content was oven dried and the various food items then separated and identified in turn by means of a dissecting or compound microscope. Then a visual estimate was made of the percentage of each item in the contents, and the findings recorded. When possible, the number of each individual prey species in each stomach contents was recorded. Trap debris such as woody stems, dirt, trap pad, and the toes, claws, and hair of the trapped animal were recorded, but were not considered in the category of food. For each analysis, a data card was made out and subsequently filed. As illustrated in Figure 1, which is an example of the type

Canis latrans Sex ad. ♂ Date 11/5/41 No. 1509
State California Co. Lassen Loc. Horse Lake
Hr. Collector M.J. Thompson Coll. No. 4770
Stom. 300 cc. Crop cc. Anim. 100 % Veg. % Grit 30 cc. 10 %
Examined by C.M. Fenel Date 3/31/42

Sylvilagus nuttallii	50 %	135.0	cc
Peromyscus sp.	20 %	54.0	cc
Ovis aries	10 %	27.0	cc
2 Microdipodops sp.	10 %	27.0	cc
Microtus sp.	5 %	13.5	cc
Phalaenoptilus nuttallii	5 %	13.5	cc
Insect (Orthopteran)	trace	trace	

Debris (trap pad, twigs, bark, grass, coyote tooth) 10 % or 30 cc.

STATE OF CALIFORNIA—DEPARTMENT OF FISH AND GAME

45288 5-51 7500 SPO

FIGURE 1. Data card showing a stomach analysis as recorded for filing

of record card used, each stomach content was divided into two main categories: that of "food" and "trap debris." Trap debris was expressed as a percentage of the entire contents, whereas the food item, or items, were considered in themselves to total 100 percent of the contents.

In the summarization of data represented by the following tables and charts, the aggregate percentage method as described by Martin, Gensch and Brown (1946) was used to determine the volume percent of food eaten. The figures for frequency of occurrence were determined by dividing the number of occurrences of each food item in the stomachs by the total number of stomachs examined. In the calculation of the frequency of occurrence a stomach was considered to have only one occurrence of an item, even though that item may be represented by several individual prey; for example, a stomach containing three meadow mice was recorded in the frequency computation as one occurrence of meadow mouse.

PRESENTATION OF THE DATA

This paper reports on the food contents identified in 2,222 coyote stomachs together with discussion as to their significance. As such, it affords a more accurate picture of the general food habits of the coyote in California than has heretofore been presented. It is difficult to attempt to evaluate the economic status of the coyote from stomach analyses alone. Certain reliable conclusions can be drawn from such a study, but limitations are apparent in both sampling and interpretation. It should be emphasized strongly that tabulation of food habits data based on laboratory analyses does not tell directly the actual net effect of predation on the prey. For example, the presence of a food item in a coyote stomach does not tell under what circumstances the food was eaten. The item may be either a kill or carrion. Carrion is, without a doubt, one of the more important sources of food, but, with few exceptions, cannot be recognized as such by examination of stomach contents. The availability and abundance of a prey species due to seasonal or cyclic phenomena are factors affecting the food habits of a predator.

In summarizing the food habits analyses, the data is grouped into regional and seasonal categories. Grouping the data in this manner resulted in dividing the State into five regions. The authors feel that any further breakdown of data, although highly desirable, would result in a limited number of stomachs being involved, with consequent distortion arising from insufficient data. The regional setup attempts to group the data as closely as possible in accordance with habitat uniformity. Because of the diversity manifest in these regions, this objective was accomplished only in a general way. Accompanying the discussion of each region is a spot map showing the locality of the region, with the trapping sites plotted. Tables 1-5 are regional check lists of the food items identified in the stomachs expressed in volume percent and frequency of occurrence percent. Accompanying the spot map of trapping sites are two graphs. One graph gives the seasonal volume percent of principal food groupings, and the other the yearly volume percent and frequency of occurrence percent of the main food groups. Following the presentation of regional data is a compilation of the data giving the volume and frequency of occurrence of the total food eaten by California coyotes with an accompanying discussion of the food habits of the coyote in California as determined by the analyses of the 2,222 stomachs.

COASTAL REGION

Description of Region

The Coastal Region extends from Del Norte County at the northwest corner of California south to and including Ventura County. This area is bordered on the west by the Pacific Ocean and on the east by the Coast Range Mountains. Few coyotes are to be found in the north coastal areas. The majority of the coyotes collected for this study were from the woodland-grass and chaparral areas of the coastal mountains south of San Francisco.

FIGURE 2. Coastal Region showing trapping sites

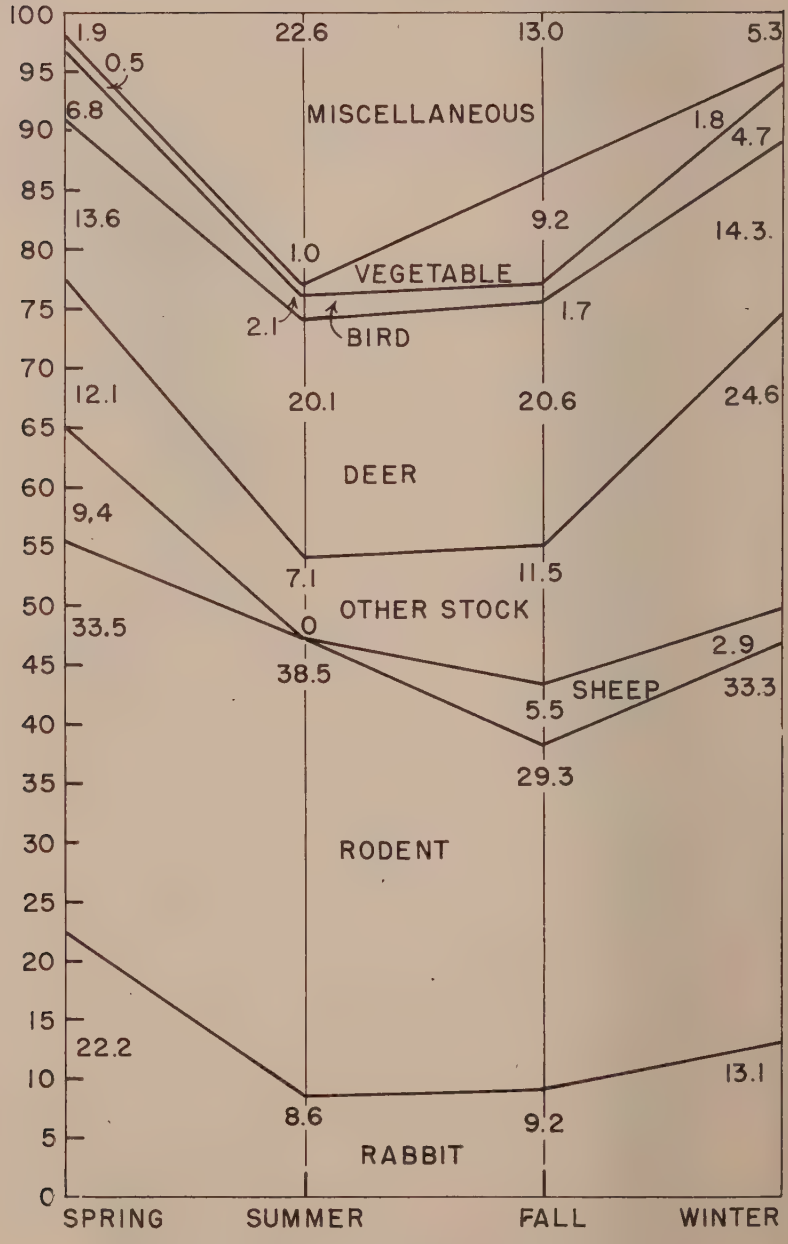

FIGURE 3. Seasonal distribution of food items eaten by coyotes taken in the Coastal Region expressed in volume percent

Food Items Identified

Rodent

In the Coastal Region rodents were the largest single item by volume percent throughout the year. Rodents in the yearly diet amounted to 33.2 percent by volume and occurred in 63.1 percent of the stomachs. The seasonal use of rodents is consistently high. Rodents occupied first place in the food intake of the coastal coyote during each season of the year. The highest use was observed to occur in the summer when it amounted to 38.5 percent by volume of diet. In the fall, a low of 29.3 percent was recorded. The meadow mouse was perhaps the most important rodent available in the Coastal Region, and was eaten with more frequency and volume in the fall and winter months than in spring and summer. Other rodents, which were sufficiently abundant in number and distribtuion to become important in the diet of the coyote, were the beechey ground squirrel, wood rat, and the pocket gopher. Cricetine rodents furnished the bulk of the other rodents eaten.

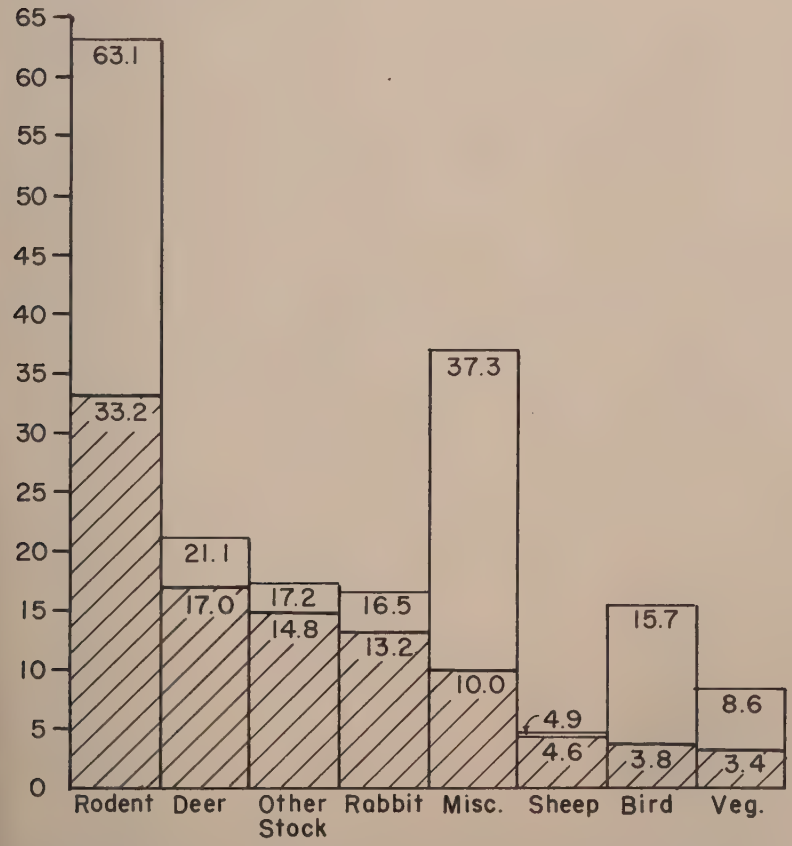

FIGURE 4. Total volume percent and frequency of occurrence in percent of food items eaten by coyotes taken in the Coastal Region arranged in order of importance by volume

TABLE 1

Check List of Food Items Taken by 407 Coyotes Collected From the Coastal Region

	Seasonal volume, percent				Total frequency of occurrence, percent*
	Spring	Summer	Fall	Winter	
Number samples	84	70	105	114	407
MAMMALS					
Opossum (*Didelphis virginiana*)			trace		0.2
Mole (*Scapanus latamanus*)			1.0		0.2
Shrew-mole) *Neurotrichus gibbsi*)				trace	0.2
Shrew (*Sorex*)				trace	0.2
Ring-tailed cat (*Bassariscus astutus*)		1.4			0.2
Bobcat (*Lynx rufus*)	1.0	1.2		1.7	1.5
House cat			1.0		0.2
Gray fox (*Urocyon cinereoargenteus*)		0.6	0.9		0.5
Coyote (*Canis latrans*)	0.8		1.0		0.5
Dog (*domestic*)				0.4	0.2
Beechey ground squirrel (*Citellus beecheyi*)	3.8	7.2	8.4	3.3	7.4
Ground squirrel (undetermined) (*Citellus*)			trace		0.2
Gray squirrel (*Sciurus griseus*)	0.6				0.2
Chipmunk (*Eutamias*)		trace			0.2
Pocket gopher (*Thomomys*)	7.0	9.2	2.5	2.9	9.1
Pocket mouse (*Perognathus*)	4.7	1.4	trace	0.9	4.7
Harvest mouse (*Reithrodontomys megalotis*)	0.7	0.2		1.0	2.2
White-footed mouse (*Peromyscus*)	2.1	1.9	trace	2.5	4.2
Meadow mouse (*Microtus*)	9.0	5.0	15.1	15.7	17.4
House mouse (*Mus musculus*)		0.2			0.2
Kangaroo rat (*Dipodomys*)		0.1	0.9	1.0	2.0
Wood rat (*Neotoma*)	4.3	13.2	1.0	2.5	7.4
Rodent (undertermined)		trace	trace	trace	1.7
Cricetine rodent (undetermined)	1.3	0.1	1.4	3.5	5.9
Jackrabbit (*Lepus californicus*)	3.6		3.1	2.4	2.0
Brush rabbit (*Sylvilagus bachmani*)			0.9	0.4	0.5
Cottontail or brush rabbit (*Sylvilagus*)	13.8	4.8	2.2	2.6	6.6
Rabbit (undetermined)	4.8	3.8	3.0	7.7	6.9
Deer (*Odocoileus hemionus*)	13.6	20.1	20.6	14.3	21.1
Cow (domestic)	12.1	7.1	7.6	23.0	15.2
Sheep (domestic)	9.4	0.0	5.5	2.9	5.0
Goat (domestic)			1.9		0.5
Pig (domestic)			2.0	1.6	1.5
Meat, bone, fat, hair (undetermined)				1.1	0.5
BIRDS					
Duck (wild)			1.0	0.9	0.5
Raptors	1.4		trace		0.7
California quail (*Lophortyx californica*)	0.4			0.2	1.0
Poultry (domestic)	2.6		trace	1.8	1.7
Galliformes (undetermined)	0.8				0.5
Passerines	1.6	0.6	0.5	1.8	4.9
Bird (other and undetermined)	trace	1.5	0.2	trace	6.4
REPTILES					
Gopher snake (*Pituophis catenifer*)		5.6	trace		2.5
Pacific rattlesnake (*Crotalus viridis*)	trace	trace	trace		1.0
Garter snake (*Thamnophis*)		trace			0.2
Racer snake (*Coluber*)		trace			0.2
Snake (undetermined)	trace	0.2	trace		2.0
Alligator lizard (*Gerrhonotus multicarinatus*)	trace	0.3			1.0
Tessellated racerunner (*Cnemidophorus tesselatus*)		trace			1.0
Fence lizard (*Sceloporus occidentalis*)	trace				0.2
Lizard (undetermined)		trace	trace		0.7
INVERTEBRATES					
Insect	0.1	11.6	7.7	2.1	21.4
Other invertebrates		1.7	0.4		1.2

TABLE 1—Continued

Check List of Food Items Taken by 407 Coyotes Collected From the Coastal Region

	Seasonal volume, percent				Total frequency of occurrence, percent*
	Spring	Summer	Fall	Winter	
VEGETABLE					
Pine nuts (*Pinus*)			0.9		0.2
Juniper berries (*Juniperus californica*)			1.8		0.7
Green grass	trace	trace	trace	trace	2.7
Fig (cultivated)			1.0		0.2
Pear (cultivated)			1.0	trace	0.7
Apricot (cultivated)			0.5		0.5
Cherry (cultivated)		0.2			0.2
Plum (cultivated)	0.5				0.2
Holly-leaf cherry (*Prunus ilicifolia*)			1.0	0.9	0.5
Coffee berry (*Rhamnus*)				0.9	0.2
Grape (cultivated)			0.8		0.2
Manzanita berry (*Arctostaphylos*)		0.7	2.2		2.0
Other wild fruits		trace			0.7
MISCELLANEOUS					
Garbage		0.1		trace	0.2
Manure (horse or cow)			1.0		0.2

* An additional 34 stomachs containing trace items only included in determining the total frequency of occurrence.

Deer

Deer ranks second in importance in the diet of the coastal coyote. Over the yearly period deer totalled 17.0 percent by volume, and was present in 21.1 percent of the coyote stomach samples. Seasonal use of deer was high throughout the year, showing an upward trend during the summer and fall months. The deer ranging throughout the coastal region north of San Luis Obispo County is the Columbian black-tailed deer (*Odocoileus hemionus columbianus*). The range of the California mule deer (*O. h. californicus*) extends southeasterly into San Luis Obispo, Santa Barbara, and Ventura Counties, with some intergradation with the Columbian black-tailed deer on the Monterey-San Luis Obispo border area (Cowan, 1936). The deer season in past years has opened usually in the central and south coastal areas in the month of August and has remained open to mid-September. In the extreme north coastal counties, deer season generally extends from late September to mid-October. Undoubtedly the loss of deer through crippling and illegal kills during the hunting season contributes considerably to the increased occurrence of deer in the diet during summer and fall. Certainly the coyote readily takes advantage of the deer which have been crippled or illegally killed and abandoned in the field.

Livestock (Other Than Sheep)

Livestock other than sheep ranked third in status in the yearly coyote diet, having bulked 14.8 percent by volume and 17.2 percent by occurrence. Cow remains made up 89.3 percent of total intake of livestock. Seasonal use of cow was high in winter and spring, being 23.1 percent and 12.1 percent of the diet respectively during those two seasons. Two occurrences of goat and six of pig were recorded. The assumption is

made by the authors that almost all of the cow eaten by coyote is carrion. The occurrence of goat and pig may have been carrion or possibly domestic stock preyed upon by coyote. Worthy of note is the fact that a substantial population of feral swine occurs in certain coastal localities and their young would undoubtedly be susceptible to predatory activities of coyotes.

Rabbit

Rabbit constituted 13.2 percent by volume and occurred in 16.5 percent of the stomach contents listed in the yearly diet. The three rabbit species occurring in the coastal region are the Audubon cottontail (*Sylvilagus audubonii*), the brush rabbit, and the blacktailed jackrabbit. Of these three, the brush rabbit occurs more commonly in the immediate vicinity of the coast, whereas the jackrabbit and cottontail appear more abundantly inland. Figure 3 reveals an increase in the intake of rabbits during the spring months amounting to 9 percent over the average for the year. The coyote undoubtedly can capture more rabbits during the spring than in other seasons due to greater availability of young rabbits at that time of year.

Miscellaneous Food Items

Coyote dietary items categorized as miscellaneous totaled 10.0 percent of the diet and was found in 37.3 percent of the stomachs. In addition to feeding upon other carnivores, coyotes commonly devour their own kind. Evidence of bobcat, gray fox, and ringtailed cat appeared in coyote stomach contents, as well as remains of a domestic cat and dog. It is likely that this material represents carrion in large part. It is common practice of trappers to use the carcasses of previously trapped animals as a trap set. Insects, too, are commonly taken by coyotes, and at certain times of the year make up a staple portion of the diet. In fact, during the summer, insects were shown to amount to 11.6 percent by volume, and occurred in 21.4 percent of the stomachs of the coastal coyote. Often, stomach analysis reveals that 100 percent of the contents prove to be grasshopper. An example of the coyote's taking of insects and spiders as food is Figure 5 which is a photograph of the stomach contents of a male pup trapped near San Simeon, San Luis Obispo County, August 8, 1942. Grasshoppers (*Melanoplus* sp.) and Jerusalem crickets (*Stenopelmatus* sp.) make up a substantial portion of insects in the coyote diet throughout the year. Beetles (Coleoptera) are taken with less frequency than orthopterons. Occasionally scorpions and centipedes are eaten in amounts which could indicate that they were not eaten by accident. Reptiles, too, were present frequently in coyote stomachs. Snake appeared in 19.8 percent of the summer stomachs and amounted to 5.8 percent of coyote diet at that time. Identification was made of the gopher snake, garter snake, racer snake, and the Pacific rattlesnake. Lizards were not eaten often. Of the 407 stomachs examined from the coastal region, only 11 showed traces of lizard. Those species of lizards identified were the alligator lizard, racerunner, and the fence lizard.

Sheep

Sheep remains made up only 4.6 percent of the food and occurred in but 4.9 percent of the coyote stomachs. The Counties of Mendocino and Humboldt are the principal sheep raising counties in the north coast.

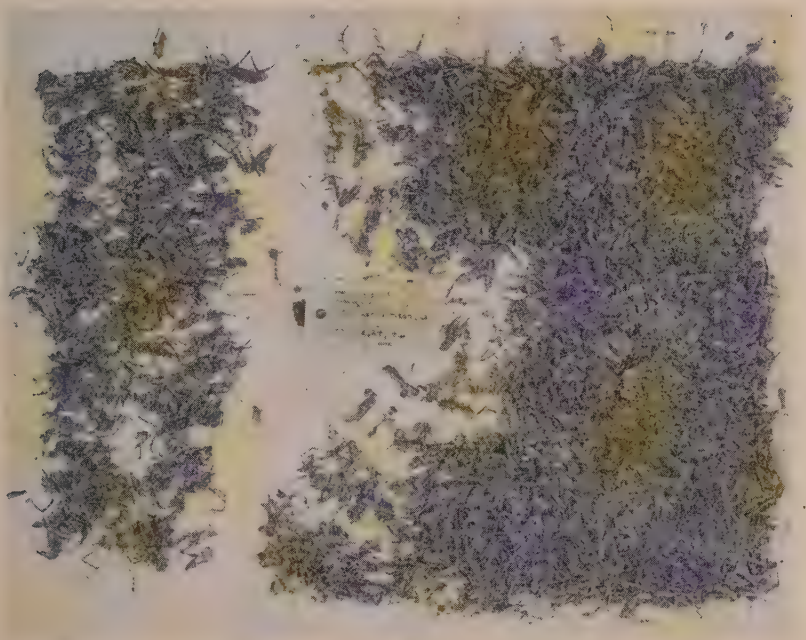

FIGURE 5. Stomach contents of a male coyote pup collected at San Simeon in August containing approximately 250 spiders and 640 grasshoppers

Lambing occurs generally in February and March, with the exception in the south coast, where ideal conditions exist for earlier lambing (Miller, 1930). The highest period of sheep consumption appeared in the spring, when it amounted to 9.4 percent of the diet, and the lowest in the summer when only a trace of sheep was to be found. Sheep constituted 5.5 percent and 2.9 percent of coyote diet in the fall and winter respectively.

Bird

The occurrence of bird in the stomachs amounted to 15.7 percent, but only furnished 3.8 percent of the total diet of the coastal coyote. Poultry, although infrequently found, bulked 30.3 percent of total bird intake. Chicken was found in five stomachs and domestic duck in two stomachs. California quail, which is the principal game bird occurring in the coastal region, appeared in but four stomachs and amounted to 4.0 percent of bird eaten. The majority of the birds eaten by coyotes were passerines, which amounted to 30.5 percent of all bird eaten. Identified among them were the song sparrow (*Melospiza melodia*), towhee (*Pipilo* sp.), California jay (*Aphelocoma californica*), western meadow lark (*Sturnella neglecta*), and the California thrasher (*Toxostoma redivivum*). The remainder of bird eaten proved to be a California woodpecker (*Melanerpes formicivorus*), a barn owl (*Tyto alba*), an undetermined owl, a gallinaceous bird, and a wild duck.

Vegetable

Vegetable food was found in 8.6 percent of the stomachs analyzed, but made up only 3.4 percent of the total yearly food. The coyote's animal fare is supplemented in the late summer and fall in the Coastal Region by cultivated and wild fruits. Coyotes are known to take a variety of cultivated fruits when available. Those eaten by the coastal coyote were apricots, grapes, figs, cherry, prunes, and pears. Of the wild fruits, the berries of California juniper and manzanita were eaten in the greatest quantity. Other wild fruit eaten were holly-leaf cherry, western choke cherry (*Prunus demissa*), buckthorn (*Rhamnus californica*), sugar-bush (*Rhus ovata*), and the nuts of the pinon pine (*Pinus cembroides*) which occurs in a restricted locality in the southern part of the region.

NORTHEAST REGION

Description of Region

The Northeast Region encompasses the entire northeastern part of the State, including the Counties of Siskiyou, Modoc, Shasta, Lassen, Plumas, and the eastern parts of Sierra and Nevada Counties. An examination of the chart showing trapping sites (Figure 6) reveals that

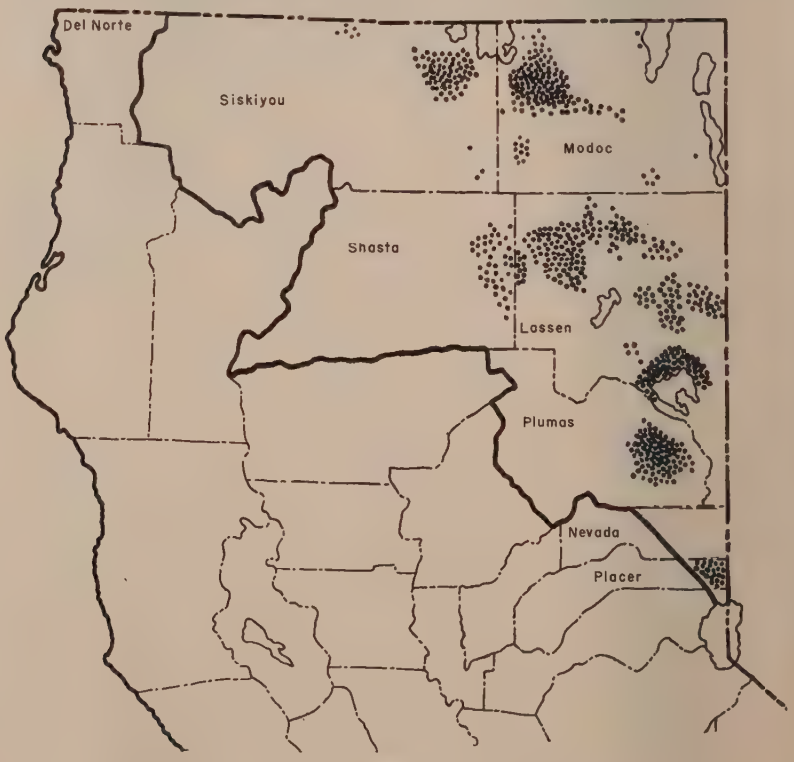

FIGURE 6. Northeast Region showing trapping sites

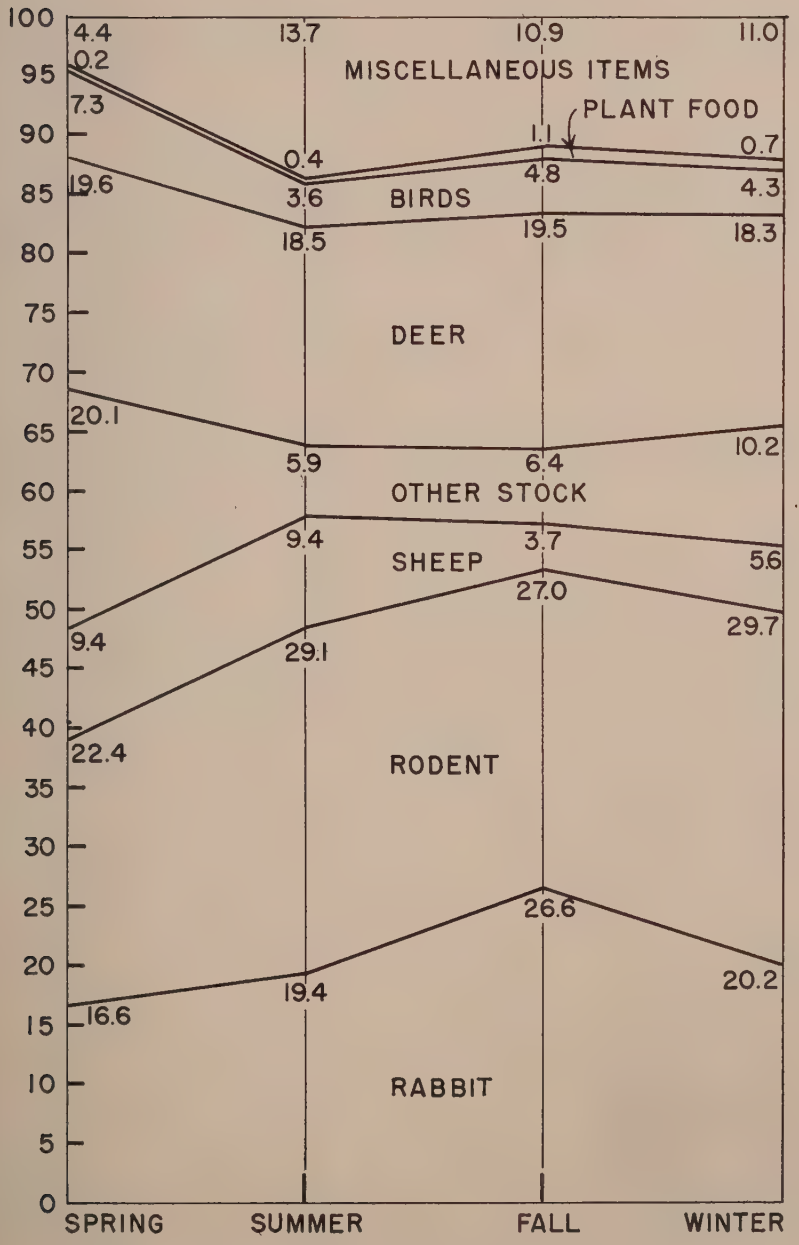

FIGURE 7. Seasonal distribution of food items eaten by coyotes taken in the Northeast Region expressed in volume percent

the majority of the coyotes were trapped from that portion of the region east of the crest of the Cascade-Sierra mountains, considered to be "great basin" in type.

Food Items Identified

Rodent

Rodents combined to make up 27.0 percent of the volume, and 49.8 percent of the occurrences of food items in the stomachs of coyotes from the Northeast Region. Meadow mice proved to be by far the most important rodent item in the diet, having been eaten in quantity in all seasons. Porcupine, by volume and total frequency, was second in importance among rodent diet staples, having been taken during all seasons of the year and rising to peak intake in winter when it amounted to 12.1 percent of the total food taken by 71 coyotes. The consumption of ground squirrel was found to be nearly equal to that of porcupine, reaching a high of 8.1 percent of the coyote summer diet. Those species eaten were identified as the beechey ground squirrel, belding ground squirrel, townsend ground squirrel, and the golden mantled ground squirrel. Other sciurids eaten were the chipmunk, chickaree, grey squirrel, and flying squirrel. Cricetine rodents formed the bulk of the remainder of rodents taken.

Rabbit

Rabbit entered into the coyote diet in the amount of 22.2 percent by volume, and occurred in 32.1 percent of the stomachs. Much of the rabbit in the stomachs was not identifiable as to species. The blacktailed jackrabbit is the commonest species in the area, and undoubtedly contributed most of the coyote's food. It constituted the bulk of the rabbit identified in the stomachs. Rabbits were taken by the coyotes throughout the year,

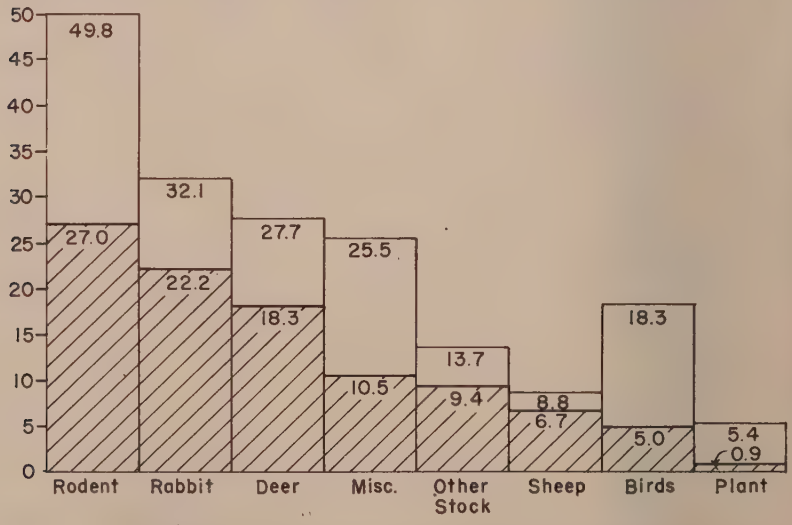

FIGURE 8. Total volume percent and frequency of occurrence in percent of food items eaten by coyotes taken in the Northeast Region arranged in order of importance by volume

TABLE 2

Check List of Food Items Taken by 611 Coyotes Collected From the Northeast Region

	Seasonal volume, percent				Total frequency of occurrence, percent
	Spring	Summer	Fall	Winter	
Number samples	106	171	263	71	611
MAMMALS					
Mole (*Scapanus latamanus*)		0.4		0.7	0.7
Shrew (*Sorex*)			0.2		0.2
Bat (*Myotis*)		trace	0.1		0.5
Coon (*Procyon lotor*)			0.4	1.4	0.3
Weasel (*Mustela*)		0.9			0.3
Spotted skunk (*Spilogale gracilis*)		0.3	0.1		0.3
Striped skunk (*Mephitis mephitis*)			0.8		0.3
Coyote (*Canis latrans*)	2.6	6.3	4.4	1.2	5.2
Bobcat (*Lynx rufus*)			0.4		0.3
Carnivore (undetermined)			0.4		0.3
Marmot (*Marmota flaviventer*)	2.4	3.3	0.4		2.3
Beechey ground squirrel (*Citellus beecheyi*)	1.1	5.4	1.6	1.5	4.7
Belding ground squirrel (*Citellus beldingi*)	0.4	0.9	0.4		0.8
Golden-mantled ground squirrel (*Citellus lateralis*)	0.2	1.8	0.5		2.0
Townsend's ground squirrel (*Citellus townsendi*)			0.2		0.2
Chipmunk (*Eutamias*)		1.9	2.1		3.4
Chickaree (*Sciurus douglasi*)	trace	1.3	0.3	trace	1.3
California gray squirrel (*Sciurus griseus*)				0.3	0.5
Flying squirrel (*Glaucomys sabrinus*)			0.4		0.2
Squirrel (undetermined)	trace	1.3	0.2	trace	2.5
Pocket gopher (*Thomomys*)	0.5	1.6	0.2	trace	2.5
Pocket mouse (*Perognathus*)	0.1	0.6	0.2		1.8
Kangaroo rat (*Dipodomys*)	1.0	0.6	0.3		1.6
Kangaroo mouse (*Microdipodops*)			trace		0.2
Harvest mouse (*Reithrodontomys megalotis*)	0.1	0.3	0.5	0.4	1.5
White-footed mouse (*Peromyscus*)	0.3	1.3	1.7	0.1	4.1
Wood rat (*Neotoma*)				1.5	0.3
Bushy-tailed wood rat (*Neotoma cinerea*)		0.6	1.3		0.8
Cricetine rodents (undetermined)	0.2	0.1	1.0	1.1	3.3
Meadow mouse (*Microtus*)	12.2	6.3	11.6	10.1	18.7
Short-tailed meadow mouse (*Lagurus curtatus*)	0.4	0.1	0.6		1.5
Microtine rodent (undetermined)	trace	trace	0.7	1.5	2.0
House mouse (*Mus musculus*)				trace	0.2
Jumping mouse (*Zapus*)			trace		0.2
Porcupine (*Erithizon epixanthum*)	2.4	1.4	2.0	12.1	6.5
Rodents (undetermined)	0.2	0.4	0.8		3.6
Pika (*Ochotona shisticeps*)	0.7				0.2
White-tailed jackrabbit (*Lepus townsendi*)	0.5		0.2		0.3
Jackrabbit (*Lepus californicus*)	4.6	5.1	9.0	10.6	8.3
Cottontail rabbit (*Sylvilagus nuttalli*)	0.8	1.2	2.7		2.3
Rabbits (undetermined)	9.7	13.1	14.8	10.6	22.3
Deer (*Odocoileus hemionus*)	19.6	18.4	19.4	18.2	27.7
Cow (domestic)	13.1	3.3	4.3	5.3	10.1
Sheep (domestic)	9.4	9.4	3.7	5.6	8.8
Goat (domestic)	0.9		0.4		0.3
Horse (domestic)	3.3	2.6	0.9	4.9	3.9
Pig (domestic)	2.8		0.8		0.8
Meat, bone, fat, hair (undetermined)	0.9	1.3	1.5	6.3	2.8
BIRDS					
Canada geese (*Branta canadensis* spp.)	1.9		0.6		0.8
Ducks (wild)	1.7	0.4	1.2	0.7	1.6
Sage grouse (*Centrocercus urophasianus*)	1.2		0.4		0.7
Gallinaceous birds (other)		trace	1.3	1.7	2.1
Coot (*Fulica americana*)			0.2	1.3	0.3
Passerine birds	1.7	2.6	0.2	0.7	4.3
Birds (all others)	1.7	0.6	0.9	trace	10.5

TABLE 2—Continued

Check List of Food Items Taken by 611 Coyotes Collected From the Northeast Region

	Seasonal volume, percent				Total frequency of occurrence, percent
	Spring	Summer	Fall	Winter	
REPTILES					
Garter snake (*Thamnophis*)	-------	-------	trace	trace	1.0
Gopher snake (*Pituophis catenifer*)	-------	0.1	0.1	-------	0.8
Snake (undetermined)	-------	trace	0.4	trace	2.0
Fence lizard (*Sceloporus occidentalis*)	1.1	trace	trace	-------	0.5
Skink (*Eumeces*)	trace	-------	-------	-------	0.2
Reptile (undetermined)	-------	-------	trace	trace	0.5
INVERTEBRATES					
Insects	trace	4.4	2.1	trace	15.4
Invertebrates (all other)	-------	trace	-------	-------	0.5
PLANT FOOD					
Choke-cherry (*Prunus demissa*)	-------	-------	0.1	-------	0.2
Manzanita (berries) (*Arctostaphylos*)	0.3	0.3	0.6	-------	2.1
Other fruits, nuts	-------	trace	trace	-------	0.5
Grass (green leafage)	trace	0.1	0.4	0.7	3.1
MISCELLANEOUS					
Leather	-------	-------	trace	1.5	0.3

with a high peak of use occurring in the fall. Of the rarer lagamorphs, one occurrence of a pika and two of the white-tailed jackrabbit were recorded. Of the Sylvilagus group, the Nuttall cottontail occurs in that region, and the pigmy cottontail (*Sylvilagus idahoensis*) is localized in the extreme northeast. Fourteen occurrences of Nuttall cottontail were identified.

Deer

Deer make up 18.3 percent of the volume, occurring in 27.7 percent of the stomachs taken in the northeast region. This proves to be the highest use of deer in any of the five regions under study. This deer is the migratory Rocky Mountain mule deer (*O. h. hemionus*) wintering on the valley floors and lower slopes and moving into the higher ranges during the summer. The general trend in recent years has been toward an overpopulation of deer on many of the winter ranges in the great basin area, accomplished by losses during the critical winters. It was expected that the high in deer use would be in the late winter months or early spring, coincident with the winter die-off; however, the analyses of coyote stomachs revealed a consistently high utilization of deer throughout the year. In the summer, there were 51 occurrences of deer in the 171 stomachs examined, of which 14 were definitely recorded as being fawns. Ten of these fawn occurrences came in the month of June concurrent with the fawning season, in the Northeast Region.

Miscellaneous Food Items

Miscellaneous food items made up 10.5 percent of the food eaten, and occurred in 25.5 percent of coyote stomachs. Coyote remains were found in 32 of the stomachs. It must be accepted that the majority, if not the

total, of the coyote eaten, is carrion. Other carnivores eaten contributed to the list of miscellaneous food items, and included bobcats, striped and spotted skunks, racoon, and weasel. Unidentified bone, flesh, and fat were found every period of the year, the peak occurring in winter. Snake was infrequently eaten in the Northeast Region, having occurred but 22 times in the total. The occurrence of insects increased considerably in the summer (4.4 percent) and fall (2.1 percent) months, but made up little of the total diet. Those insects most eaten were grasshoppers, Jerusalem crickets, and several species of beetles.

Livestock (Other Than Sheep)

Livestock other than sheep occurred in 13.7 percent of coyote stomachs, and made up 9.4 percent of the yearly diet. This livestock consisted principally of cow remains, and showed a high seasonal usage of 10.2 percent, and 20.1 percent of the winter and spring diets. The presence of livestock carrion on the range undoubtedly provides an important source of food for the coyote during the lean winter and early spring months. Coyotes have been observed to utilize a range carcass repeatedly until nothing remains but the bones, which in turn are chewed upon. Among the stomachs analyzed were 24 occurrences of horse, five of pig, and two of goat.

Sheep

Sheep was found in 8.8 percent of the stomachs and bulked 6.7 percent of the yearly diet. Seasonal high was recorded in the spring and summer months. Considerable numbers of sheep are grazed in this region, constituting one of the principal industries in the Northeast. The sheep are wintered on the many ranches in the valleys, and are driven to higher ranges to graze in May and June. Lambing period is during February and March. How much of the sheep present in the coyote stomachs can be attributed to carrion or predation is a matter of conjecture and cannot be determined from stomach analyses. Bond (1939) attributed the loss of only 12 sheep to coyotes of the 10,500 sheep grazed on the Lava Beds National Monument Range during the course of his study on coyote food habits.

Bird

Bird remains made up 5.0 percent of the total volume of food, and occurred in 18.3 percent of the stomachs. Most of the occurrences were passerine and unidentified bird remains. Those passerine birds identified and having occurred twice each were the California jay, horned lark (*Otocoris alpestris*), and western bluebird (*Sialia mexicana*). Those occurring once were blackbird, brewer blackbird (*Euphagus cyanocephalus*), varied thrush (*Ixoreus naevius*), robin (*Turdus migratorus*), song sparrow, and the marsh wren (*Telmatodytes palustris*). Other birds identified were the sparrow hawk (*Falco sparverius*), poorwill (*Phalaenoptiles nuttalli*), and the white pelican (*Pelecanus erythrorhynchos*), with one occurrence apiece, and the coot and the red-shafted flicker occurring twice. Five occurrences of Canada goose were recorded, two being found in the spring, and three in the fall. Of the 10 duck occurrences, three were present in the spring diet. Upland game birds taken were identified as sage grouse, which occurred four times;

mountain quail, which occurred twice, and ring-necked pheasant, occurring twice. Only one incidence of dove was recorded in the total yearly food intake of the northeast coyote.

Vegetable

Plant food was found to be relatively unimportant in the diet of the northeastern coyote. The only plant food found in the stomachs analyzed were the berries of manzanita and chokecherry, and green grass, which was eaten in only rare instances. Cultivated fruits did not appear in any of the stomachs that were examined.

INLAND-SIERRA REGION

Description of Region

The Inland-Sierra Region comprises the area extending from the junction of the Coast Range Mountains and the Sierra Nevada Mountains at the northern extremity of the Sacramento Valley to the southern limit of the San Joaquin Valley bordered by the Tehachapi Mountains. The eastern boundary is the crest of the Sierra and the western boundary is the Coast Range Mountains. The majority of the coyote stomachs were collected from the foothills surrounding the Central Valley.

Food Items Identified

Rodent

The number one item in the diet of the inland coyote is rodent. This comprised 24.5 percent of the yearly diet occurring in 46.8 percent of the stomachs. The sciurids were the principal rodents eaten amounting to 34.2 percent of the total yearly rodent intake. The bulk of squirrel eaten was identified as beechey ground squirrel. As might be expected, few ground squirrels are eaten during winter months due to the fact that the ground squirrel generally hibernates. Pocket gopher and meadow mouse comprised 18.4 and 16.9 percent respectively of the rodent diet. Other rodents contributing in appreciable amounts to the coyote diet were pocket mice, deer mice, and wood rats. A trace of porcupine appeared in one coyote stomach.

Rabbit

Rabbit ranked second in the diet of the inland coyote. Rabbit totaled 29.0 percent in occurrence, and amounted to 22.9 percent of the yearly food eaten. The most abundant rabbits in the valley and foothill areas are the black-tailed jackrabbit and the audubon cottontail. It is very likely that some of the Sylvilagus identified among stomach contents were the brush rabbit which is found in the Sierra from 600 to 6,700 feet in elevation. The seasonal diet of rabbit varied little with the highest consumption noted in the summer months when it was 30.7 percent of the diet and was found in 34.6 percent of the stomachs.

Livestock (Other Than Sheep)

Livestock, principally cow and horse remains, bulked 12.1 percent of the contents in 15.4 percent of the stomachs analyzed. Quantity of livestock eaten varied with the season, being low in summer (5.1 percent)

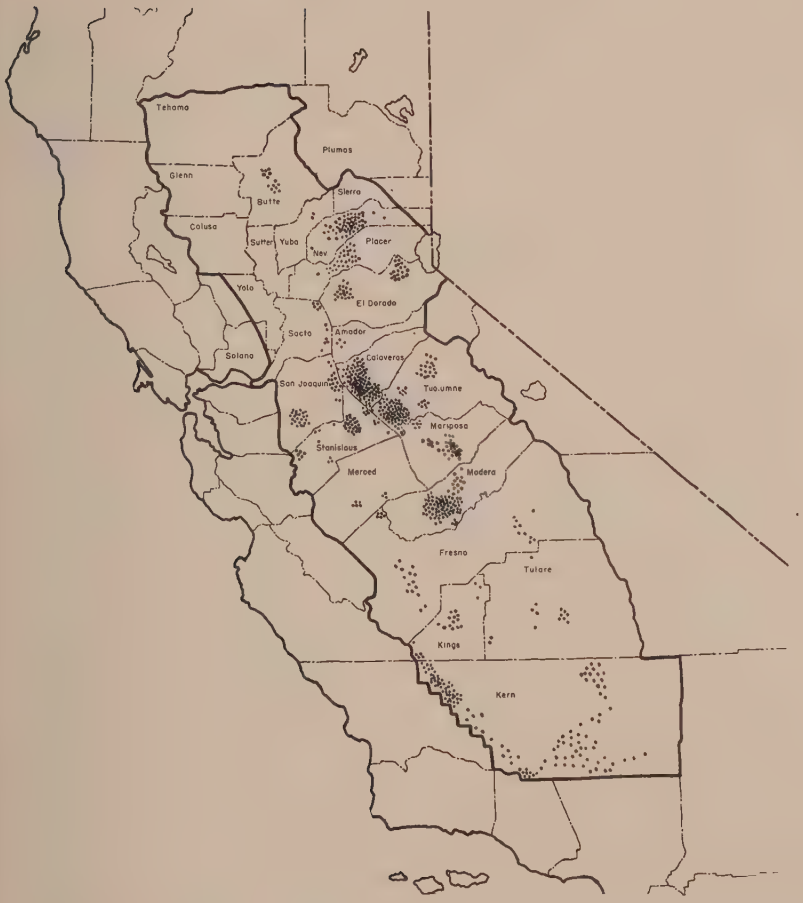

FIGURE 9. Inland-Sierra Region showing trapping sites

and high in winter (11.8 percent). This would be expected, as the bulk of livestock eaten is considered to be carrion, which is more available on the range during winter than summer. Goat found in the stomachs made up 7.6 percent of livestock contents, and pig occurred in but one stomach.

Deer

Deer amounted to 11.4 percent of the diet of the inland coyote and was found in 14.1 percent of the stomachs analyzed. Both the Columbian black-tailed deer and the California mule deer inhabit the Inland-Sierra Region. The highest usage of deer occurs in spring when it made up 18.9 percent of the coyote diet. The availability of the fawn crop in spring may contribute to the increase of deer in coyote stomach contents recorded at this season. The second high deer total was concurrent with

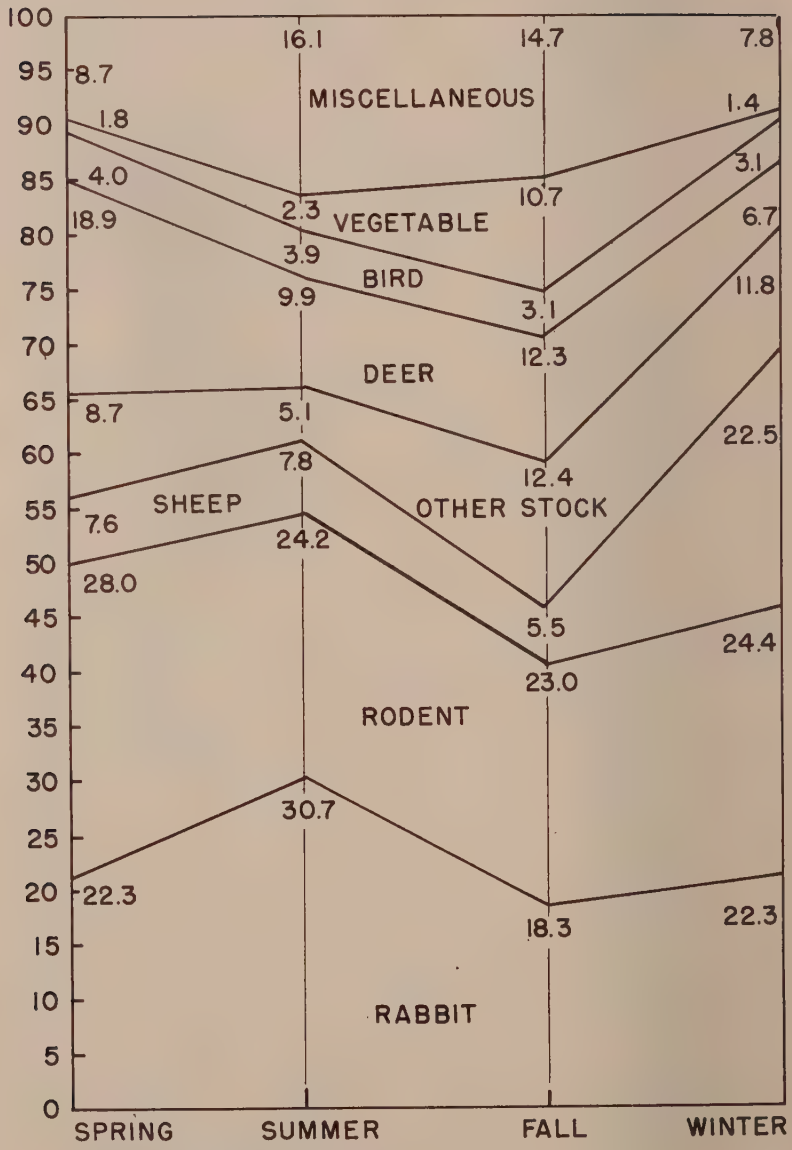

FIGURE 10. Seasonal distribution of food items eaten by coyotes taken in the Inland-Sierra Region expressed in volume percent

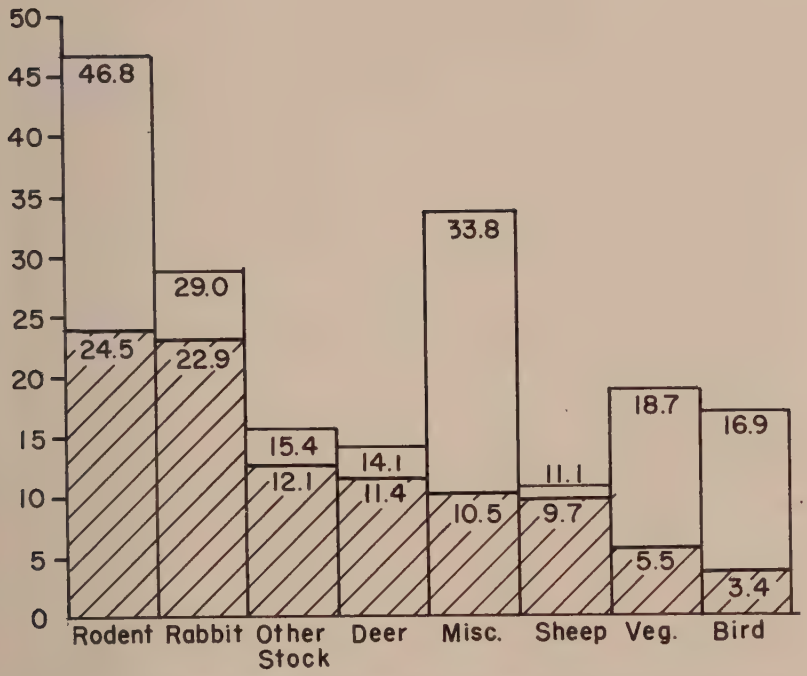

FIGURE 11. Total volume percent and frequency of occurrence in percent of food items eaten by coyotes taken in the Inland-Sierra Region arranged in order of importance

the hunting season in the fall when it amounted to 12.3 percent of the diet.

Miscellaneous Food Items

The aggregate of food items listed as miscellaneous totaled 10.5 percent in volume and 33.8 percent in frequency of occurrence. Included in this group was a substantial quantity of insect food amounting to 4.8 percent of the summer and 5.1 percent of the fall diets. Grasshoppers and Jerusalem crickets were evidently the most avidly devoured insects. It was not uncommon to find stomachs full or partially full of grasshoppers. The Jerusalem cricket was frequently eaten, but not in the same quantity as the grasshoppers. The undetermined bone, meat, and fat found in the stomachs contributed an appreciable quantity of the miscellaneous food items, but there was very little variability in seasonal trend. Consumption of this food was consistently high throughout the year. Skunk occurred in 10 stomachs, coyote in six; badger, coon and bobcat each appeared once. Shrew and mole remains were found in two stomachs, and a hoary bat had been eaten by a coyote. Gopher snake outnumbered other snakes as a food item, being found in 13 stomachs. Other snakes identified were the pacific rattlesnake and a racer. Unidentified snake remains were found in an additional 14 coyote stomachs. The greatest occurence of snake was recorded in summer, when it contributed 2.0 percent to the total summer diet. Lizards were eaten occasionally by the

TABLE 3

Check List of Food Items Taken by 813 Coyotes Collected From the Inland-Sierra Region

	Seasonal volume, percent				Total frequency of occurrence percent*
	Spring	Summer	Fall	Winter	
Number samples	106	196	281	164	813
MAMMALS					
Mole (*Scapanus latamanus*)		0.6			0.2
Shrew (*Sorex*)	trace				0.5
Hoary bat (*Nycteris cinerea*)			trace		0.1
Coon (*Procyon lotor*)		0.5			0.1
Striped skunk (*Mephitis mephitis*)		0.7	1.4	0.5	1.2
Badger (*Taxidea taxus*)		0.5			0.1
Coyote (*Canis latrans*)		1.5	0.7		0.7
Bobcat (*Lynx rufus*)		0.5			0.2
Marmot (*Marmota flaviventer*)			0.3		0.1
Beechey ground squirrel (*Citellus beecheyi*)	6.3	6.5	9.0	1.9	9.1
Golden mantled ground squirrel (*Citellus lateralis*)		0.1	0.4	0.6	0.4
Chipmunk (*Eutamias*)		0.7	0.2		0.4
Ground squirrel (undetermined)	1.9	2.9	trace		1.6
Chickaree (*Sciurus douglasi*)	0.5			trace	0.2
Gray squirrel (*Sciurus griseus*)	0.5		0.2		0.2
Pocket gopher (*Thomomys*)	6.7	2.4	4.2	6.1	8.6
Pocket mouse (*Perognathus*)	2.6	3.4	0.8	0.8	3.9
Kangaroo rat (*Dipodomys*)		1.0	1.7	1.3	2.2
Heteromyid rodent (undetermined)			0.7	0.4	0.4
Harvest mouse (*Reithrodontomys megalotis*)	trace	1.2		1.3	1.2
White-footed mouse (*Peromyscus*)	2.7	0.1	0.4	1.4	3.8
Wood rat (*Neotoma*)		2.6	0.9	0.6	2.1
Cricetine rodent (undetermined)	1.0	trace	trace	2.8	1.8
Meadow mouse (*Microtus*)	5.6	2.7	4.2	4.8	6.9
House mouse (*Mus musculus*)	0.1	trace	trace	1.2	0.7
Jumping mouse (*Zapus*)		0.1			0.1
Porcupine (*Erithizon epixanthum*)	0.1				0.1
Rodents (undetermined)		0.5	trace	1.2	2.1
Jackrabbit (*Lepus californicus*)	8.8	10.0	7.6	6.7	9.3
Cottontail rabbit (*Sylvilagus nuttalli*)	1.0		1.3	1.1	1.1
Brush or cottontail rabbit	3.5	8.0	1.8	2.4	4.3
Rabbit (undetermined)	9.0	12.7	7.6	12.1	14.3
Deer (*Odocoileus hemionus*)	18.9	9.9	12.3	6.7	14.1
Cow (domestic)	7.7	1.6	8.8	10.8	9.3
Sheep (domestic)	7.6	7.8	5.5	22.5	12.3
Goat (domestic)	1.0	1.5	1.4	0.6	1.4
Horse (domestic)		2.0	2.1	0.4	1.6
Pig (domestic)			0.1		0.1
Meat, bone, fat, hair (undetermined)	6.0	4.5	6.2	6.1	5.4
BIRDS					
Coot (*Fulica americana*)				trace	0.1
White-fronted goose (*Anser albifrons*)				1.0	0.2
Ducks (wild)		0.5			0.4
Mourning dove (*Zenaidura macroura*)			trace		0.1
Raptors	0.9	1.2	0.4		0.9
Ring-necked pheasant (*Phasianus colchicus*)		trace			0.1
Mountain quail (*Oreortyx picta*)		trace			0.1
Valley quail (*Lophortyx californica*)			trace		0.1
Poultry (domestic)	trace	0.4	0.5	0.1	2.0
Galliformes (undetermined)	0.2		0.4	0.7	0.9
Passerines	1.3	1.5	0.8	trace	3.9
Bird (other and undetermined)	1.6	0.3	1.0	1.3	8.2

TABLE 3—Continued

Check List of Food Items Taken by 813 Coyotes Collected From the Inland-Sierra Region

	Seasonal volume, percent				Total frequency of occurrence, percent*
	Spring	Summer	Fall	Winter	
REPTILES					
Gopher snake (*Pituophis catenifer*)		1.2	0.5		1.6
Pacific rattlesnake (*Crotalus viridis*)		0.7	0.1		0.5
Racer snake (*Coluber*)				trace	0.1
Snake (undetermined)	trace	0.1	0.1		1.7
Skink (*Eumeces*)		trace			0.1
Fence lizard (*Sceloporus occidentalis*)	0.2	0.2	0.2		0.9
Lizard (undetermined)	trace	trace	trace		0.4
INVERTEBRATES					
Insects	0.6	4.8	5.1	0.7	20.3
Invertebrates (all other)		0.3	trace		1.0
VEGETABLE					
Pine nuts (*Pinus*)	trace	trace	1.1		1.0
Juniper berries (*Juniperus californica*)		0.7	1.9		2.0
Green grass	1.8	0.3	0.8	0.3	7.6
Fig (cultivated)		1.1	1.7		1.7
Peach (cultivated)			0.4		0.1
Pear (cultivated)			trace	0.5	0.2
Holly-leaf cherry (*Prunus ilicifolia*)			0.3		0.4
Watermelon (cultivated)			0.4		0.2
Vitis sp. (cultivated)		0.2	1.0	0.3	1.2
Manzanita berry (*Arctostaphylos*)			3.0	0.3	3.4
Other wild fruits			0.1		0.4
MISCELLANEOUS					
Cow and horse manure	1.7	trace	0.4	0.5	0.7
Leather	0.2		trace		0.2

* An additional 66 stomachs containing trace items included in determining total frequency of occurrence.

inland coyote. Western fence lizard was the most common lizard taken. A skink also was identified as eaten. On occasion coyotes will eat horse or cow manure. One coyote stomach collected in September contained 75 percent horse manure, and 95 percent of the stomach contents of a coyote collected in April consisted of cow manure. A piece of well chewed leather was found in one stomach.

Sheep

Sheep remains were found in 11.1 percent of the stomachs and constituted 9.7 percent of the diet. The sheep raising industry in California is most highly developed in the foothill areas of the Sierra Nevada and coast range mountains bordering the Sacramento and San Joaquin Valleys. This region provides grazing and lambing grounds in the winter, and grazing on national forests during the late spring and summer months. The practice of sheep men is towards early lambing, the lambs being dropped in December and January. The winter months contributed the highest volume of sheep amounting to 22.5 percent of the diet. Lamb losses, winter losses in adult sheep available as carrion, and predation on the lambs, undoubtedly would manifest themselves in the increased consumption of sheep in the winter diet of the inland coyote.

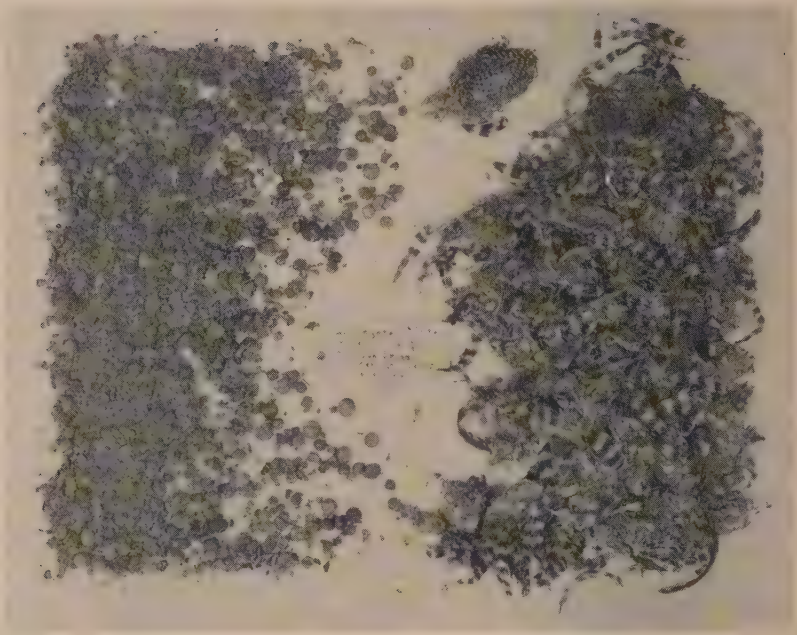

FIGURE 12. The stomach contents of a coyote collected August 8, 1942, at San Emigdio, Kern County, containing approximately 200 manzanita berries making up 38 percent of the contents. Chicken (61 percent) and skink lizard (1 percent) constitute the remainder of the contents.

Vegetable

Vegetable food appeared in 18.7 of the stomachs, and supplied 5.5 percent of the total yearly diet. It contributed an appreciable part of the fall diet amounting to 10.7 percent of the food. Outstanding among the wild fruits eaten were berries of manzanita and California juniper. Other wild fruits identified were wild plum (*Prunus* sp.), holly-leaf cherry, buckthorn and poison oak (*Rhus diversiloba*). Worthy of interest is the presence of pine nuts in some of the stomachs. Pine nuts of the sugar pine (*Pinus lambertiana*) were found to make up 90 percent of the contents in the stomach of an adult female coyote collected in Tuolumne County in October. Another Tuolumne coyote stomach contained 100 percent pine nuts of ponderosa pine (*Pinus ponderosa*). Green grass was eaten in appreciable amounts in September and October coinciding with the new grass growth of the late fall months. As expected, consumption of cultivated fruits proved highest in August and September. It consisted principally of grape, fig, peach and pear. Watermelon occurred twice, and constituted 100 percent of one coyote's fare.

Bird

Bird remains appeared in 16.9 percent of the stomachs, but amounted to only 3.4 percent of the total yearly diet of the inland coyote. The majority of the bird occurrence consisted principally of unidentified bird remains, usually traces of feathers. Passerines eaten made up 25.5

percent of the total bird diet. Also identified were remains of the meadowlark, junco (*Junco* sp.), California jay, blackbird (*Agelaius* sp.), crow (*Corvus brachyrynchos*), mountain bluebird (*Sialia currucoides*), and spotted towhee (*Pipilo maculatus*). Of these birds, meadowlark occurred in five stomachs. Poultry totaled 9.2 percent of the bird eaten, chicken being found in 14 stomachs and turkey in two. The amount of game bird eaten proved negligible, only one occurrence of each of the following being recorded: valley quail, mountain quail (egg), pheasant, and dove. Duck remains were found in only three stomachs. Raptorial birds identified were the cooper hawk (*Accipiter cooperi*), great horned owl, (*Bubo virginianus*), and the red-tailed hawk (*Buteo borealis*). Unidentified hawk remains in one stomach, and the occurrence of owl in two coyotes made up the balance of raptors eaten. A considerable percentage of raptors eaten were probably available as carrion, for it is a commonplace sight in the foothill areas to observe hawk remains hanging from fences where they have been placed by the roadside hunter. The remainder of bird consisted of three occurrences of red-shafted flicker (*Colaptes cafer*) and one instance of the road runner (*Geococcyx californianus*).

EASTERN REGION

Description of Region

The Eastern Region is bounded on the east by the Nevada line and on the west by the crest of the Sierra Nevada. It is a mountainous area interspersed with valleys, the largest of which is Owens Valley extending from Bishop at the northern end with an elevation of 4148 feet, to Owens Lake at the southern end with an elevation of 3550 feet. It is from Owens Valley that the majority of coyotes were trapped.

Food Items Identified

Rabbit

Rabbit was by far the most important single item eaten by the coyote in the Eastern Region. Of the yearly diet, rabbit constituted 41.5 percent and occurred in 48.9 percent of the stomachs examined. The volume and frequency of occurrence of rabbit eaten throughout the year remained consistently high, with the lowest point occurring in the fall. The black-tailed jackrabbit is the most common rabbit in the Eastern Region, occurring in both the sagebrush and cultivated areas in varying degrees of profusion. The white-tailed jackrabbit is a species which occupies the higher elevations of the Sierra Nevada. There locally it undoubtedly is an important food of the coyote inhabiting that elevation, but it is rarely found with the exception of during the winter in the Owens Valley area. In this region, only the Nuttall cottontail, of all the members of the Sylvilagus genus, occurs; and nowhere is it as abundant as the jackrabbit.

Rodent

Rodent ranked second in importance as food to the coyote in the Eastern Region. It totaled 19.2 percent of the food eaten, and was found in 41.5 percent of the stomachs examined. More rodents were consumed in the summer and fall than in the winter and spring periods. Foremost rodent in coyote diet of the Eastern Region was the meadow mouse,

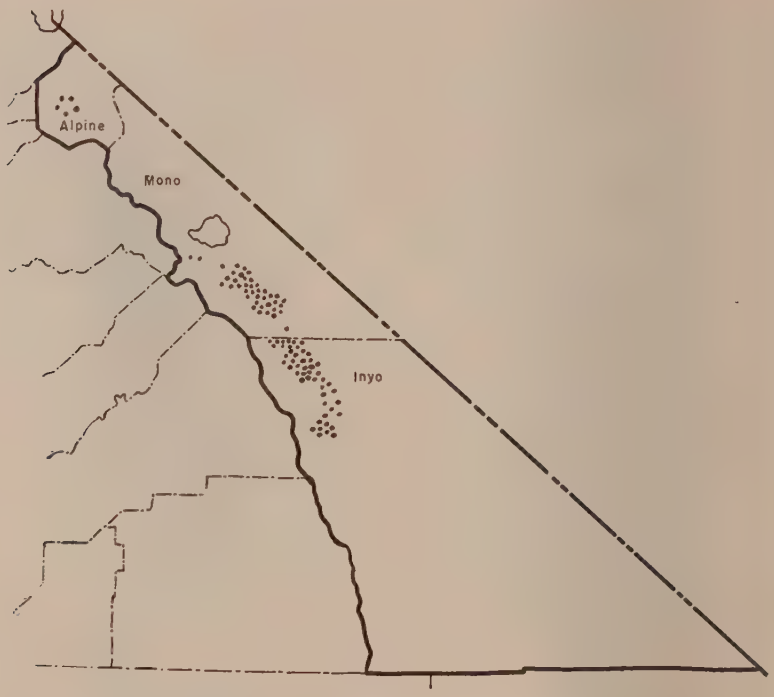

FIGURE 13. Eastern Region showing trapping sites

which constituted 50.0 percent of the fall, and 55.3 percent of the winter rodents eaten. Ground squirrel appeared in stomachs throughout the year, with the peak of consumption during the summer months when it amounted to 44.3 percent by volume of the rodent diet. Cricetine rodents formed the bulk of the other rodents eaten in the Eastern Region.

Miscellaneous Food Items

Coyote food items listed as miscellaneous constituted 12.4 percent of the yearly diet, and occurred in 40.4 percent of coyote stomachs analyzed. The bulk of the miscellaneous food items were unidentified meat, bone, fat and hair, which made up 89.1 percent of this category in the fall season. What amount of this flesh and bone consisted of carrion in the form of cow, horse, sheep, or deer carcasses could not be determined. As a result, it was categorized "miscellaneous." Also found in the coyote stomachs of this region were the identified remains of a striped skunk, bobcat, and house cat, with one occurrence apiece. Of two coyote stomachs examined, the broad-footed mole made up 40 percent and 60 percent of the contents. Snake was present in five stomachs of the 40 coyotes collected in the fall. In October, a great basin gopher snake constituted 50 percent of the stomach contents of one coyote. A garter snake was also identified in a stomach, and one occurrence of lizard was recorded. Insects proved to be of negligible importance in this region, occurring in only 19 of the 94 coyote stomachs analyzed.

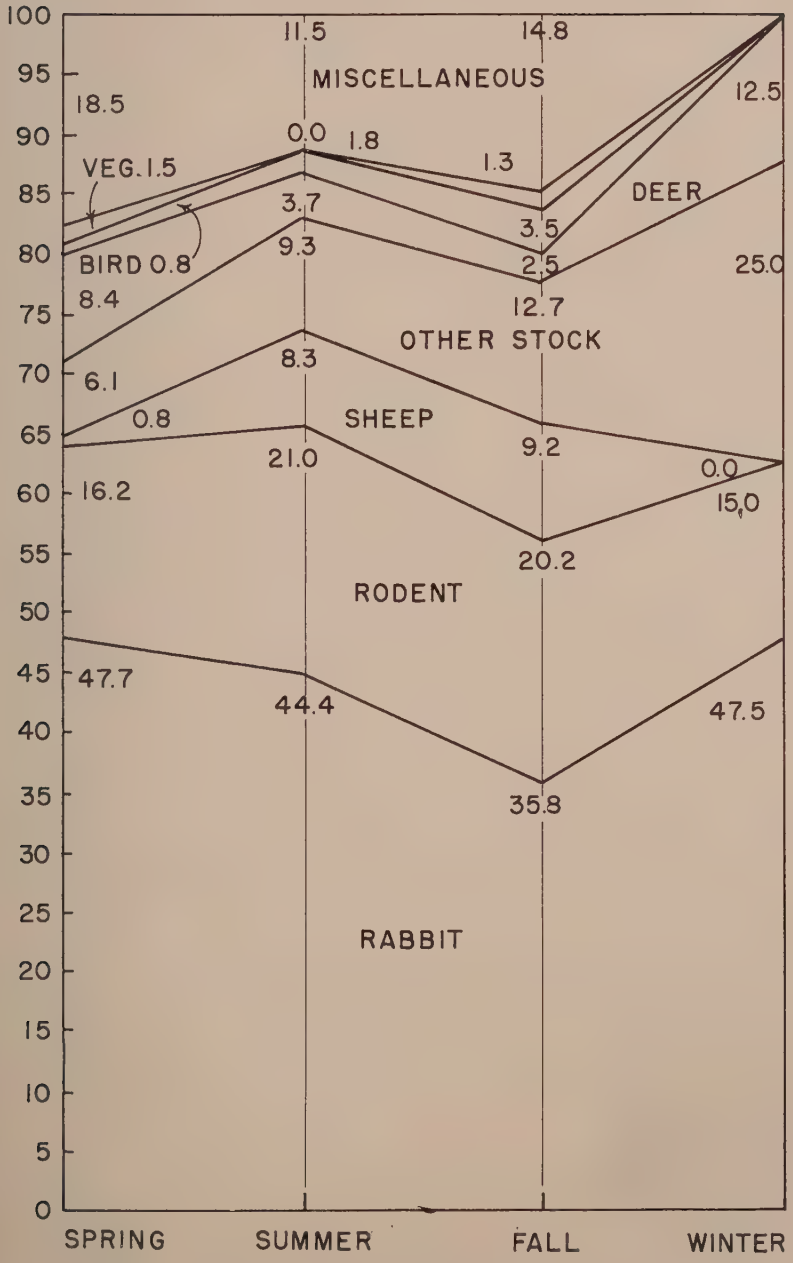

FIGURE 14. Seasonal distribution of food items eaten by coyotes taken in the Eastern Region expressed in volume percent

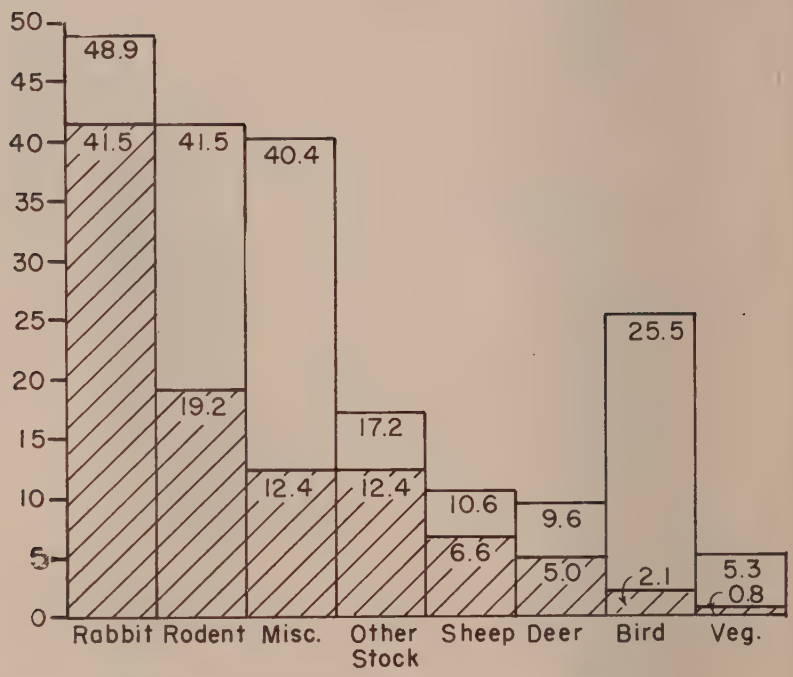

FIGURE 15. Total volume percent and frequency of occurrence in percent of food items eaten by coyotes taken in the Eastern Region arranged in order of importance by volume

Livestock (Other Than Sheep)

The occurrence of livestock other than sheep made up 17.2 frequency percent and 12.4 volume percent of the yearly diet. The quantity of cow eaten varied with the seasons, being nonexistent in coyote stomachs collected in the spring, and rising to 25.0 percent by volume of the winter diet. One occurrence each of goat and horse was found.

Sheep

Sheep remains were found in 10.6 percent of the coyote stomachs examined, and totaled 6.6 percent of the yearly food. Sheep raising practices in the three counties of Alpine, Inyo, and Mono are much like those in the Northeastern Region. The relatively few coyote stomach samples collected in the winter and spring in the Eastern Region precludes any analysis of the consumption of sheep on a seasonal basis.

Deer

Deer totaled 5.0 percent of the yearly diet and occurred in 9.6 percent of the coyote stomachs. Two races or subspecies of deer inhabit the Eastern Region—the Rocky Mountain mule deer and the Inyo mule deer (*O. h. inyoensis*). Both are migratory, inhabiting the lower elevations in the winter and the higher mountains in summer. The seasonal distribution of deer in coyote stomachs from this region held no valid significance as few coyote samples were taken in the winter and spring.

TABLE 4

Check List of Food Items Taken by 94 Coyotes Collected From the Eastern Region

	Seasonal volume, percent				Total frequency of occurrence, percent*
	Spring	Summer	Fall	Winter	
Number samples	13	27	40	12	94
MAMMALS					
Mole (*Scapanus latamanus*)	3.1	2.2			2.1
Striped skunk (*Mephitis mephitis*)		3.7			1.1
Bobcat (*Lynx rufus*)	7.8				1.1
House cat (domestic)	3.8				1.1
Beechey ground squirrel (*Citellus beecheyi*)	3.8		1.6	4.2	3.2
Golden-mantled ground squirrel (*Citellus lateralis*)		9.0			4.3
Squirrel (undetermined)		0.3			1.1
Pocket gophers (*Thomomys*)		4.8			2.1
Pocket mouse (*Perognathus*)	3.8				2.1
Kangaroo rat (*Dipodomys*)				2.5	1.1
White-footed mouse (*Peromyscus*)		3.7	1.5		4.3
Wood rat (*Neotoma*)			0.4		1.1
Cricitine rodent (undetermined)		1.9			1.1
Meadow mouse (*Microtus*)	0.8	1.1	10.1	8.3	11.7
Microtine rodent (undetermined)	7.8		0.6		2.1
Rodent (undetermined)	trace	trace	6.0	trace	7.4
Jackrabbit (*Lepus californicus*)	3.8	10.9	15.3	30.9	16.0
Cottontail rabbit (*Sylvilagus*)		10.7	2.5	8.3	5.3
Rabbit (undetermined)	43.9	23.0	18.0	8.3	27.7
Deer (*Odocoileus hemionus*)	8.4	3.7	2.5	12.5	9.6
Cow (domestic)		9.3	10.2	25.0	14.9
Sheep (domestic)	0.8	8.3	9.2		10.6
Goat (domestic)	6.1				1.1
Horse (domestic)			2.5		1.1
Meat, bone, fat, hair (undetermined)		3.7	13.2		7.4
BIRDS					
Waterfowl (wild)		0.4	0.1		3.2
California quail (*Lophortyx californica*)			0.2		2.1
Ring-necked pheasant (*Phasianus colchicus*)			1.0	trace	2.1
Passerines	0.8	0.6	0.9	trace	9.6
Raptors			1.3		1.1
Bird (undetermined)		0.8	trace		7.4
REPTILES					
Garter snake (*Thamnophis*)			0.1		1.1
Gopher snake (*Pituophis catenifer*)			1.2		1.1
Snake (undetermined)		1.9	trace		4.3
Lizard			trace		1.1
INVERTEBRATES					
Insects	3.8	trace	0.3	trace	20.2
VEGETABLE					
Pear (cultivated)		trace	1.3		2.1
Green grass	1.5				3.2

* Two additional stomachs containing trace items only included in the frequency of occurrence calculations.

The majority of the 94 coyotes taken were obtained from Owens Valley, which constitutes the winter range, but not the summer range of the Inyo mule deer.

Bird

Bird amounted to but 2.1 percent of the yearly coyote diet, although it occurred in 25.5 percent of the stomachs analyzed. The principal upland game birds of this area are the mountain quail, the valley quail, and the sage hen. Pheasants have been introduced into the cultivated areas along Owens' River. Upland game bird remains were found in four coyote stomachs, two coyotes having eaten valley quail in October and two having eaten pheasant in November and December. Waterfowl remains were found in three stomachs, and passerine birds in eight stomachs. Two passerine birds were identified as the horned lark and the meadowlark. A marsh wren and unidentified hawk remains were recorded in the stomach contents analyses. Unidentified bird remains made up the remainder, having been found in seven coyote stomachs in this region.

Vegetable

Vegetable food contributed very little to the diet of the Eastern Region coyote. It amounted to but 0.8 percent of the diet and occurred in 5.3 percent of the stomachs. The only vegetable food recorded in the 94 stomachs was green grass eaten in the spring, and two occurrences of pear in the fall.

SOUTHERN REGION

Description of Region

The Southern Region is that part of the State including the Counties of Los Angeles and San Bernardino south to Baja California. This region, with the exception of that portion adjacent to the coast, is one of desert and semidesert valleys interspersed with mountain ranges.

Food Items Identified

Rabbit

Rabbit was the most important item in the coyote diet in the Southern Region of the State. It amounted to 26.4 percent by volume and occurred in 35.3 percent of the stomachs analyzed. Consumption of rabbit was highest in the winter and spring months when it was 30.3 percent and 40.5 percent of the total volume of food for those respective seasons. Black-tailed jackrabbits, Audubon cottontails, and brush rabbits all occur in this region, the brush rabbits being more predominant in the coastal portion of the region.

Rodent

Rodent was second in importance by volume but first in number of occurrences in the yearly diet of the coyote in the Southern Region. Rodents made up 24.4 percent of the volume and occurred in 37.7 percent of the stomachs examined. Meadow mouse contributed most of the bulk of the rodent eaten. Wood rats were an important food item throughout

FIGURE 16. Southern Region showing trapping sites

the year, with a seasonal peak of use occurring in the spring. The heteromyids, consisting of the kangaroo rats and pocket mice, with the addition of the beechey ground squirrel, formed the remainder of the bulk of rodents eaten. The hispid cotton rat, which occurred five times in the coyote stomachs examined, has a restricted distribution in California, occupying areas along the Colorado River and in the Imperial Valley. This rat could possibly be an important source of rodent food for the coyote occurring in that locality.

Miscellaneous Food Items

The food items categorized as miscellaneous totaled 10.3 percent of the diet and were present in 21.8 percent of the coyote stomachs. Carnivores eaten were the spotted skunk, badger, and dog, with one occurrence apiece; striped skunk occurred twice, bobcat five times, and coyote twelve times. Of the reptiles eaten, rattlesnake occurred in four stomachs, and gopher snake in three. Remains of fish were found six times, but these occurrences were attributed to the coyotes having eaten trap bait used by a trapper who was contributing coyote stomachs from this region. Insects as food again supplemented the summer and fall diets, amounting to 8.1 percent of the summer food and consisting mainly of grasshoppers and Jerusalem crickets.

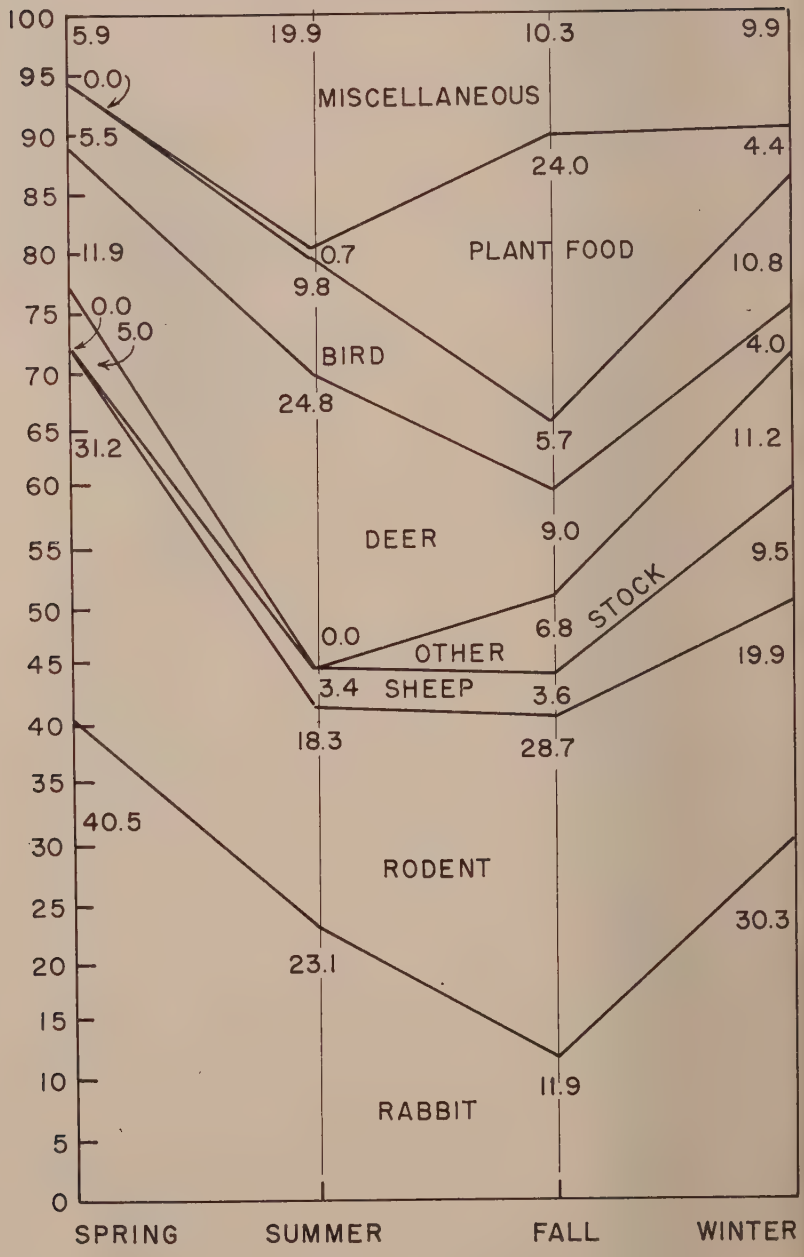

FIGURE 17. Seasonal distribution of food items eaten by coyotes taken in the Southern Region expressed in volume percent

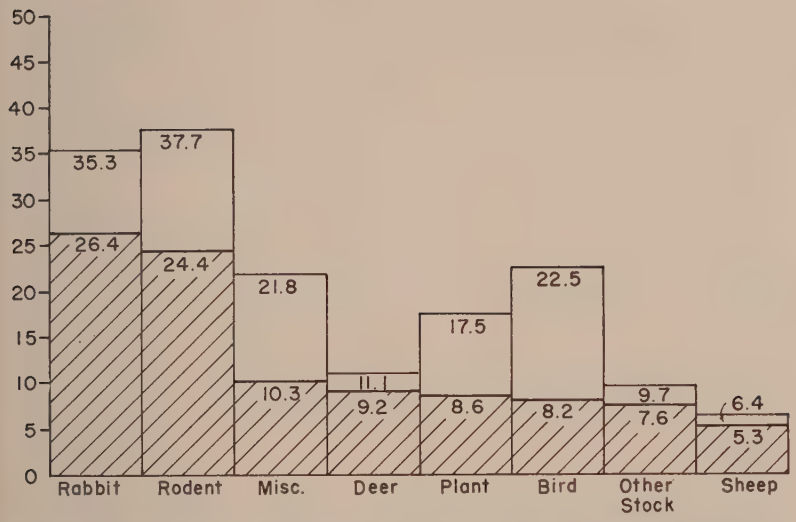

FIGURE 18. Total volume percent and frequency of occurrence in percent of food items eaten by coyotes taken in the Southern Region arranged in order of importance by volume

Deer

Deer remains constituted 9.2 percent of the food and occurred in 11.1 percent of the coyote stomachs of the Southern Region. The highest usage of deer was in the summer when it made up 24.8 percent of the diet. Spring proved to have the second highest consumption of deer, amounting to 11.9 percent. Of the 145 coyote stomachs collected in Los Angeles County in an area inhabited by the California mule deer, there were 24 occurrences of deer. Six of these occurrences, or 25 percent, were identified as being fawns. Spring fawning and the occurrence of the late summer deer season could be contributing factors to account for the apparent seasonal trend in deer utilization in the Southern Region.

Vegetable

Plant food amounted to 8.6 volume percent of the total food consumed and occurred in 17.5 percent of the coyote stomachs. Of the five regional areas studied, the consumption of vegetable food was greatest in the Southern Region. Plant food accounted for 24 percent of the coyote diet in the fall, and included a large variety of cultivated fruits. Eaten were the fruits of date, pear, grape, apricot, cherry, plum, watermelon, fig, and English walnut. Most important of the wild fruit in the stomachs were the drupes of holly-leaf cherry and the berries of manzanita. Other fruits of noncultivated plants eaten were mesquite beans, coffee berry, and toyon berries (*Photinia arbutifolia*). The consumption of grass which occurred in the fall and winter was negligible.

TABLE 5

Check List of Food Items Taken by 297 Coyotes Collected From the Southern Region

	Seasonal volume, percent				Total frequency of occurrence, percent
	Spring	Summer	Fall	Winter	
Number samples	59	31	83	124	297
MAMMALS					
Spotted skunk (*Spilogale gracilis*)		2.9			0.3
Striped skunk (*Mephitis mephitis*)		2.3	0.2		0.7
Badger (*Taxidea taxus*)	0.1				0.3
Coyote (*Canis latrans*)			3.4	6.2	3.7
Dog (domestic)			1.1		0.3
Bobcat (*Lynx rufus*)	4.1		1.1	0.8	1.7
Beechey ground squirrel (*Citellus beecheyi*)	3.4	5.6	1.0	3.4	5.4
Chipmunk (*Eutamias*)	1.7				0.3
California gray squirrel (*Sciurus griseus*)			1.7		0.7
Pocket gopher (*Thomomys*)		2.7	1.2	0.8	2.0
Pocket mouse (*Perognathus*)	0.3	0.3	0.5	0.2	3.7
Kangaroo rat (*Dipodomys*)	1.4		2.7	2.4	4.7
Heteromyid rodent (undetermined)				0.8	0.3
Harvest mouse (*Reithrodontomys megalotis*)			0.7		0.7
White-footed mouse (*Peromyscus*)	1.7		0.6	trace	1.0
Cotton rat (*Sigmodon hispidus*)			5.0		1.7
Wood rat (*Neotoma*)	11.7	3.2	6.7	1.8	7.4
Cricetine rodent (undetermined)	1.8	trace		2.4	2.7
Meadow mouse (*Microtus*)	5.5	6.5	7.2	7.3	9.4
House mouse (*Mus musculus*)	1.7		0.2		1.0
Rodent (undetermined)	2.0	trace	1.2	0.8	3.4
Jackrabbit (*Lepus californicus*)	1.4	3.2	1.6	7.8	6.4
Domestic rabbit (domestic)		1.6			0.3
Cottontail rabbit (*Sylvilagus nuttalli*)				1.6	0.7
Brush or cottontail rabbit (undetermined)	15.1	12.5	6.3	7.7	11.1
Rabbit (undetermined)	24.0	5.8	4.0	13.2	17.2
Deer (*Odocoileus hemionus*)	11.9	24.8	9.0	4.0	11.1
Cow (domestic)	3.4	trace	4.3	8.8	7.1
Sheep (domestic)		3.4	3.6	9.5	6.4
Goat (domestic)	1.6		1.3	0.8	1.3
Horse (domestic)			1.2	0.8	0.7
Pig (domestic)				0.8	0.3
Meat, bone, fat, hair (undetermined)	0.9		2.4	0.8	3.7
BIRDS					
Raptorial birds	0.2			1.2	1.0
California quail (eggs only)		1.0			0.3
Gambel quail (*Lophortyx gambeli*)			0.1		0.3
Poultry (domestic)	5.2	8.8	1.8	7.3	8.1
Passerines	0.1		2.7	0.1	4.4
Birds (Miscellaneous and undetermined)	trace	trace	1.1	2.2	10.8
REPTILES and FISH					
Gopher snake (*Pituophis catenifer*)		0.2	trace	0.8	1.0
Rattlesnake (*Crotalus*)	0.8	0.3	0.8		1.3
Snake (undetermined)			trace		1.0
Alligator lizard (*Gerrhonotus*)			0.3		0.7
Lizard (undetermined)				trace	0.3
Fish (mostly trap bait)		6.1	0.6	1.0	2.0
INVERTEBRATES					
Insects	trace	8.1	0.4	0.3	8.1
Miscellaneous invertebrates			trace		1.3

TABLE 5—Continued

Check List of Food Items Taken by 297 Coyotes Collected From the Southern Region

	Seasonal volume, percent				Total frequency of occurrence, percent
	Spring	Summer	Fall	Winter	
VEGETABLE					
Dates (cultivated)			1.6	trace	1.0
Pears (cultivated)				1.6	1.0
Grapes (cultivated)			2.4	0.8	2.0
Miscellaneous cultivated fruits		0.4	0.3	0.4	2.4
Holly-leaf cherry (*Prunus ilicifolia*)			10.6	1.2	5.1
Mesquite (seeds, pods) (*Prosopis juliflora*)			1.8		1.7
Manzanita berries (*Arctostaphylos*)		0.3	6.1	trace	3.4
Miscellaneous fruits			1.2	0.3	1.0
Grass (green leafage)			trace	0.1	2.4

Bird

Bird remains were 8.2 percent of the food taken in the Southern Region and occurred in 22.5 percent of the stomachs. Poultry made up 67 percent of the birds eaten having been found in 24 coyote stomachs The finding of but one occurrence of eggs of the California quail and the remains of one gambel quail constituted the only game birds eaten. Raptors eaten were the sparrow hawk (*Falco sparverius*), and an unidentified species of hawk and owl. Of the 12 occurrences of passerine birds, three were identified, California jay being eaten twice, and the horned lark and bluebird (*Sialia sp.*) once each. The remains of a road runner were found in one coyote stomach from the Southern Region.

Livestock (Other Than Sheep)

Livestock occurred in 9.7 percent of the coyote stomachs examined and made up 7.6 percent of the total coyote diet. Peak consumption of livestock occurred during the fall and winter months. Cow was the principal item, occurring in 21 stomachs out of the total analyzed. Other domestic stock recorded were two occurrences of horse, one of pig, and four of goat.

Sheep

Sheep remains amounted to 5.3 volume percent of the diet, and occurred in 6.4 percent of the coyote stomachs. The highest consumption of sheep occurred in the winter when it made up 9.5 percent of the diet. The sheep industry is not as extensive in the Southern Region, as in other areas in California. Much of the sheep raising is limited to fenced permanent pastures, particularly so in the Imperial Valley.

DISCUSSION OF RESULTS

Figure 19 is the compilation of the previous regional data and represents the summarization of the principal food items eaten by 2,222 coyotes over the entire State of California. Each item is in turn discussed as was done in the regional presentation in order of importance as determined by total volume percent.

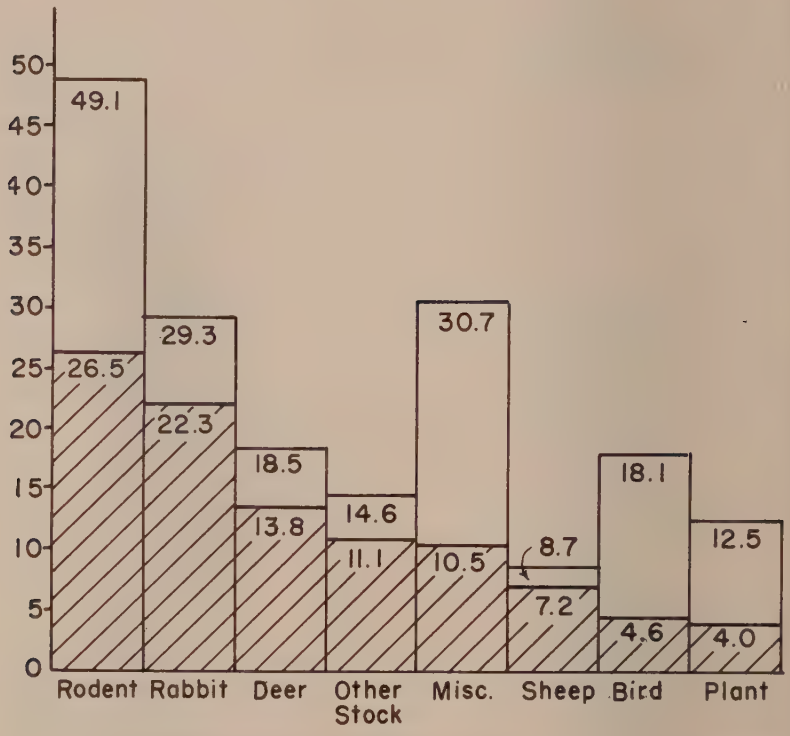

FIGURE 19. Total volume percent and frequency of occurrence in percent of food items eaten by 2,222 California coyotes arranged in order of importance by volume

Food Items Identified

Rodent

The staple food of the California coyote is rodents. It was the number one item both in volume percent and number of occurrences. Rodents occurred in 49.1 percent of the stomachs and amounted to 26.5 percent of all the food found in California coyotes. Meadow mice are undoubtedly the most important, having headed the list of rodent species eaten in all the five regions with the exception of the Inland-Sierra. Murie (1935) found meadow mice (field mice) to be the number one item in the diet of the coyote in Jackson Hole, Wyoming. Cricetine rodents, notably the wood rats and deer mice, contribute the second largest share of the rodent diet. The beechey ground squirrel, which is plentiful throughout most of California, is another rodent taken in great quantity. It apparently forms a staple item in the diet of the coyote inhabiting the foothill areas surrounding the Central Valley. The pocket gophers, kangaroo rats, and pocket mice form the bulk of the remainder of the rodent diet. An exception to this was in the Northeastern Region where porcupine was second in importance in the rodent food, having been eaten throughout the year and contributing 12.1 percent of the entire winter food. Apparently, the coyote is quite capable of capturing and devouring a porcupine, and its predation on porcupines is decidedly beneficial, as the

porcupine is considered to be a detriment to the silviculture practice in the northeast. The significance of rodent in the diet of the coyote has been brought out by both Murie (1940) and Sperry (1941). Murie ranked rodent as number one in importance in the diet of the coyote in Yellowstone National Park and Sperry placed it as third in order of importance in his coyote study.

Rabbit

Rabbit took second place in the diet of the coyote in California, bulking 22.3 percent of the diet and being found in 29.3 percent of the stomachs. The jackrabbit and cottontail rabbits were the most frequently taken of the lagomorphs with the exception perhaps in the coastal areas where the brush rabbit is much more abundant. Sperry (1941) found rabbit to be the number one item of the diet in the 8,339 stomachs analyzed by the Fish and Wildlife Service. Fitch (1947), in a study on the ecology of the cottontail rabbit in central California, asserts that the combined toll of predation by all types of predators is a major factor, if not the decisive one in limiting cottontail distribution and abundance. Of the wildlife species predatory on cottontails, the coyote was first in order of importance. The contents of 1,173 coyote scats were analyzed in this study and the results were computed on the basis of percentage weight of the total prey. Cottontail was 45.4 percent of the diet of the coyote on the San Joaquin experimental range. The final analysis of the regional data reveals that the utilization of the rabbit was the highest in the southern and eastern regions and was consistently high throughout the year in all regions, the peaks occurring in the spring and winter.

Deer

Deer remains in the coyote stomachs were surprisingly high, forming 13.8 percent of the total diet and were found in 18.5 percent of the stomachs. The greatest consumption of deer computed on a volume basis occurred in the spring and summer. The Northeast and Coastal Regions proved to have the highest percentage of deer in the stomachs. There is considerable variation in seasonal consumption of deer as to regions, as an examination of regional data reveals.

The presence of deer remains in a coyote stomach presents the greatest difficulty of interpretation of all the food items consumed by the coyote. Undoubtedly much deer eaten by the coyote is available as carrion. Hunter kills, crippling loss, seasonal die-offs, accidental deaths, et cetera, are all contributing factors. The serious overpopulation of deer on many of the winter ranges has resulted in recent years in abnormal losses of deer during the critical winters as a result of starvation or malnutrition. Lassen et al. (1952) cite the high mortality of mule deer, especially of fawns during the months of March and April, as the result of cumulative nutritional deficiency. Such deer, weakened by insufficient quantity and quality of food, and by a critical winter, were considered by Bond (1939) to be "statistical carrion." In terms of deer population, it mattered not whether the weakened deer were pulled down by the coyote or found dead several days later.

The same reasoning may be applied to the large crippling loss experienced during the hunting seasons. McLean (1934) found that in California 27 percent of the 100 coyotes that had eaten deer meat were

taken during, and in the month following, the deer season, and 30 percent in areas where severe weather caused a heavy deer loss, and he implied that most of the deer eaten was carrion.

That the coyote does pursue and kill healthy deer is unquestionable, as evidenced by the host of observations on the part of field observers recorded in literature. It is thought by many that predation on deer during the fawning season represents a serious inroad on the deer populations. The inability on the part of the laboratory technician for the most part to be able to distinguish fawn from adult deer in stomach contents precludes any conclusion in this study on the effect of coyote predation on fawns. It is an accepted fact that the mortality in fawns as revealed by fawn-doe ratios progressively increases from the time the fawn is dropped until it leaves the winter range as a yearling. Murie (1940) was of the opinion that there is a definite correlation between range conditions and the extent of coyote predation on deer, particularly fawns.

The effect of predation on deer by the coyote—whether beneficial or deleterious relative to management of the deer population in California—must be viewed in the light of current deer population trends. Gabrielson (1941) says in this regard: "When the herbivorous population is high and predators are in normal numbers predator pressure is obscured * * * its measurement is difficult. Under such condition predation may well become a negligible factor, and the predators, even though preying to a normal extent on deer or antelope, may still be utilizing animals that are surplus to the existence or even welfare of the herd."

To the many factors precluding any conclusion in this study as to the significance of deer being number three in importance by volume in the diet of the California coyote may also be added the thought expressed by Latham (1951): "One of the principal stumbling blocks in the way of agreement upon economics of predation is that most of those who favor predator control are thinking in terms of individual animals lost, while most of those who oppose control are usually thinking in terms of species or population survival." In this respect, in the management of deer, the loss of individual deer to the coyote is of little consequence when one analyzes the deer herd as a whole and in essence an evaluation of predation should be on the basis of the prey not the predator.

Livestock (Other Than Sheep)

Livestock remains consisting principally of cow and horse occurred in 14.6 percent of the stomachs and amounted to 11.1 percent of the diet of the California coyote. The total consumption of livestock, including that of sheep, exceeds the amount of deer eaten and would place this food third in importance. However, the sheep item in the diet has been separated in the tabulation of data from that of cow, horse, and other livestock because the authors consider the category of livestock to be largely one of carrion. Sperry (1941) classified all bovine except that recognized as calf or colt as carrion and as such it was second in importance next to rabbit in the diet of the coyote in his study. The quantity of livestock eaten by the California coyote varied seasonably, the highest consumption being during the winter months. Undoubtedly an important factor in the welfare of the coyote is the presence of livestock carcasses. They are

utilized decidedly more during winter months when other food sources are limited in availability. Included in livestock was the occurrence of goat and pig remains, but these contributed little to the volume of livestock eaten.

Miscellaneous Food Items

The food items listed as miscellaneous bulked but 10.5 percent of the total diet but occurred in 30.7 percent of the stomachs. It would be difficult to find an equal of a coyote as the role of a scavenger. It is quite apparent from stomach analyses that the coyote will eat anything it can catch or find to chew. It was quite common to find unidentified bone, flesh, fat and hair in the stomachs which for the most part had as its origin the eating of carrion of some large mammal by the coyote. This item of food was utilized the most in the fall and winter months. Insects were found to supplement the diet during the summer and fall months occurring then with greatest frequency and volume. Grasshoppers and Jerusalem crickets were the most sought after of the insects, and it was not uncommon to find stomachs full of these insects, indicative that they were deliberately taken as food. The predominance of insects in the fall and summer is explained by the seasonal abundance of insects during that time of the year. Carnivores, including the coyote itself, are often eaten by the coyote. How much of this food can be construed as carrion is a matter of conjecture. The number of occurrences of carnivore remains found in this study is as follows: coyote 51, bobcat 14, striped skunk 15, spotted skunk 3, raccoon 3, grey fox 2, ringtailed cat 1, badger 2, and weasel 2. Two occurrences each of dog and house cat were found. Other mammals included in the diet, and listed as miscellaneous were bat with 3 occurrences, and an opossum. Insectivores are generally thought to be rejected as being distasteful as food by many mammals. Mole occurred 8 times in all of those stomachs examined. Two coyotes trapped in the Eastern Region had eaten moles amounting to 40 and 60 percent of the stomach contents. There were 6 occurrences of shrews and 1 of the shrew mole. Reptiles, principally snake, were frequently found in the diet, having occurred in 131 stomachs of those examined. The gopher snake was the most commonly found, with rattlesnake being second in occurrence. Most snake was eaten during the summer months. Coyotes will occasionally eat the dung of livestock as evidenced by the finding of 7 occurrences of horse and cow manure.

Sheep

Sheep remains constituted 7.2 percent of the diet, occurring in 8.7 percent of the stomachs. That coyotes do kill sheep and exist as a detriment to the sheep raising industry is well known. The extent of depredation on sheep as might be indicated by the finding of sheep remains in 8.7 percent of the coyote stomachs is questionable. Surely the raising of sheep like that of any other livestock involves the loss of animals due to disease, loss of lambing, winter exposure, and accidental causes which would render many of these available as carrion on the range. How much of the sheep remains found in this study is from such a source is again a matter of conjecture. The consumption of the sheep was highest in the Sierra Region. The bulk of the 275 stomachs analyzed by the Fish and

Wildlife Service and embodied in this study was taken from the sheep ranges of the lower foothills of the Sierras and contributed much of the sheep identified in the 813 coyotes from this region. The consumption of sheep was rather constant over the spring, summer, and fall periods of the year with a high in evidence during the winter. Sheep raising practices, notably the time of lambing, vary regionally and the consumption of sheep is undoubtedly influenced accordingly.

Bird

Birds, although occurring frequently in the diet of coyotes, contribute only a small part of the total diet. Sperry (1941) found the occurrence of bird to be 13.0 percent, but making up only 2.9 percent of the diet. In the California coyote, bird occurred 18.1 percent and bulked but 4.6 percent of the diet. Of the bird diet, the passerine birds make up the most of bird eaten. Those passerines identified as occurring most frequently were the California jay and the meadowlark. Game birds supply a surprisingly small portion of the diet. Of the 2,222 stomachs examined, the occurrence of game birds was as follows: California quail 8 occurrences, 1 being of eggs; mountain quail 1; gambel quail 1; ring-necked pheasant 4; sagehen 3; dove 2; and waterfowl 24. The coyote has often been considered a hazard to nesting waterfowl. Sooter (1946) reported on observing 2,074 nests of waterfowl at the Malheur National Wildlife Refuge and attributed the destruction of 21 duck, 30 goose, and 2 crane nests to the coyote. There was an additional 50 coyote-type destruction of nests. He considered the coyote to be equaled only by the raven as affecting waterfowl production on the refuge. Dow (1943) who conducted a study of nesting Canada geese on Honey Lake Refuge in California, found the coyote to be responsible for more nest destruction than were all other predators combined. Waterfowl would obviously be most subject to coyote predation during the nesting and when newly hatched, but it is difficult to conceive predation to be any factor on waterfowl abundance thereafter. Coyote are known to feed on ducks in areas where botulism in the late summer and fall has taken a toll of ducks. Undoubtedly cripples are easily obtained during the hunting season in areas where the coyotes are present adjacent to hunting clubs and refuges. Poultry occurred in 51 stomachs and consisted mainly of chicken. There were two occurrences each of turkey and domestic duck. Most of the poultry eaten was in the southern region having made up 67 percent of the total bird intake for that region.

Vegetable

Vegetable food was found in 12.5 percent of the stomachs, but supplied only 4.0 percent of the total food. It was practically nonexistent in the diet of the coyote in the Eastern region, and was made up for the most part of manzanita berries and chokecherries in the Northeastern region. A large variety of cultivated fruits was eaten by the coyote elsewhere in the State, including dates, figs, pears, apricots, cherries, and watermelon. The principal wild fruits found were the fruits of manzanita, juniper, and holly-leafed cherry. Obviously such plant food would be available only during the summer and fall months. Green grass appeared in 96 stomachs and in quantity that is indicative that it was eaten as food. The greatest occurrence of grass was in the Sierra region during the spring months.

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AN EVALUATION OF THE MARINE SPORTFISHING RECORD SYSTEM IN CALIFORNIA[1]

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INTRODUCTION

The sportfishing record system in California is based on the reported daily catch of boats operating for hire in marine waters. Since 1936, the owners or operators of party fishing vessels that carry paying passengers have been required by law to keep an accurate record of the catches made from their boats. However, the mere passage of the regulation requiring daily catch records and the presentation of the forms to accomplish this does not insure that such records will be submitted or that they will be accurate. To evaluate the quality and the quantity of the sport catch records, a physical check of the boat catches was started in 1947. This consisted of an actual count, made by departmental personnel, of the fish landed on a party fishing boat. The percentage accuracy of a particular boat was determined by comparing the actual count with the written record prepared by the boat operator.

The inaccuracy of the boat records in 1947 indicated that improvement was required and during the period 1948-1951 boat catch records did prove much better in summary. In that period, fewer boats were checked that had no records, and the individual boat accuracy improved remarkably. Filling out accurate catch records at the end of each day's operation is not an easy task. Some passengers resent questioning as to the number of fish they have taken, and some do not know one species of fish from another. However, both passengers and boatmen are gradually becoming more familiar with the requirements of, and the theory behind, the record system. Sport catch records accurately compiled contain basic information essential to the fisheries biologists, to the department and to the public.

USE OF SPORT CATCH RECORDS

Catch records are utilized in an effort to trace the trend in numbers of fish caught per fisherman from a population. Through changing trends, indices of the condition of the various fisheries are obtained. Where declining return per fishing day suggests that a fishery is diminishing in production, answers to the problem are sought through biological studies and through analyses of factors other than changing abundance of the fish.

REQUIREMENTS AND FORMS

The law requires that the records shall show each day's operation, the area fished, the number of persons fishing, an accurate count by species of the number of fish taken, and their approximate weight. Booklets are distributed by the Department of Fish and Game to the owners of all registered party boats each year. Separate forms adapted to local conditions are distributed in the Northern and Central California, San Francisco Bay, and Southern California areas (Figures 1, 2, 3). A supply of postage paid envelopes is provided with each booklet distributed.

[1] Submitted for publication January, 1953.

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF FISH AND GAME

Date 12/19/51 Town of landing AVILA
Boat name DORIE Fish and Game No. 1234
Block areas fished 615 No. in party fishing 22

Indicate below number of fish of each species taken and your estimate of weight. Even if no fish are caught, state that no fish were taken and fill in other blanks. Blank lines are for species which are not shown in the list.

SPECIES		NO. OF FISH	TOTAL WT., LBS.
CABEZONE (BULLHEAD)	261	4	29
LING COD	195	5	20
FLOUNDERS, SOLE, SAND DABS	230		
HALIBUT	222		
KINGFISH	435		
MACKEREL	051		
PERCH	550		
ROCKFISH (ROCK COD)	250	36	56
BLACK ROCKFISH (BLUEFISH)	252		
YELLOWTAIL ROCKFISH	259		
SALMON	300		
SHARK	150		
SMELT	180		
SEA TROUT		1	1

95215 8-48 200 BKS. OF 150 ④
STATE PRINTING OFFICE

Nº 43523

FIGURE 1. Sportfishing record form used in Northern and Central California. The species listed are those most commonly taken by ocean fishermen between Crescent City and Avila.

Daily Log of Boat RAPID ROBERT F. & G. No. 6789 Place of Landing BERKELEY Date 5 / 16 / 52 (Month / Day / Year)

Areas Fished LIGHTSHIP (Local Name of Place) Block No. 455

ONE TRIP PER DAY BOATS FILL IN THIS SIDE	TWO TRIPS PER DAY BOATS FILL IN THIS SIDE
Number in party fishing 6	Number fishing in the morning
Approximate number of hours of fishing 7	Number fishing in the afternoon

KIND OF FISH CAUGHT	Number of Fish	Total Weight
Striped Bass		
Salmon	8	75
Flounder		
Rockfish		
Cabezone		
Lingcod		
Other Fish, Show Kind		

Kind of Bait or Lure used SPOONS - HERRING

SERIAL № 222402

REMARKS: (For convenience of operator. May be left blank if desired.)

17 UNDERSIZED SALMON RETURNED TO WATER

[SIGNED] R Collins

51654 10-51 8M DUP ④ SPO

FIGURE 2. Sportfishing record form used in the San Francisco Bay and delta regions. These records are kept in duplicate. One copy goes to the Department of Fish and Game and the other is kept by the boat operator for his convenience.

CALIFORNIA DEPARTMENT OF FISH AND GAME

Date JUNE 15, 1952 Town of landing LONG BEACH
Boat name KINGFISH Fish and Game No. 6789
Block areas fished 762 No. in party fishing 17

Indicate below number of fish of each species taken and your estimate of weight. Even if no fish are caught, state that no fish were taken and fill in other blanks. Blank lines are for species which are not shown in the list.

SPECIES		NO. OF FISH	TOTAL WT., LBS.
ALBACORE	005		
BARRACUDA	130	25	125
BONITO	003		
CABEZONE	261		
LING COD	195		
FLOUNDERS, SOLE, SAND DABS	230		
HALIBUT	222	2	8
KINGFISH (TOM COD)	435		
MACKEREL, PACIFIC	051		
ROCKFISH (ROCK COD)	250		
SAND BASS AND KELP BASS	275	59	71
SCULPIN	260	7	10
SHARK	150		
SHEEPSHEAD	145	3	9
SKIPJACK	002		
SMELT	180		
TUNA, BLUEFIN	004		
WHITEFISH	490	3	9
WHITE SEA BASS	400		
YELLOWTAIL	040	1	12

65692 7-52 1500 BKS © SPO

No 95302

FIGURE 3. Sportfishing record form used in Southern California.

BOAT CATCH CHECKS

The boat catch check consists of taking the actual count and weight of fish landed from a party fishing vessel. A set of weighing scales, suspended from a tripod, is placed where all passengers disembarking from a boat may be stopped for examination of their catch. The contents of the fisherman's sack are dumped on a tarpaulin beneath the scales, sorted by species, counted, and then weighed to the nearest quarter-pound. To conserve time, some species are sorted into general groups only. For instance, all species of rockfish are grouped, as are the flatfishes (soles, sanddabs and flounders), exclusive of California halibut.

One man counts and weighs all fish while a second records the information. A third man boards the boat and secures the catch record for the day and checks the boat operator's written record to see if all questions about the area of catch, date and number of persons fishing are answered. When the check is completed, the actual count is compared with the reported catch and the percentage accuracy determined. The boat operator is then shown the comparison between his report and the actual count. The discrepancy between the actual count and the reported catch may have caused some boat operators to consider more efficient means of obtaining accurate catch records.

RESULTS

The actual counts and the boat reports have been summarized to show total numbers by species (Table 1). Boat report figures are expressed as a percentage of the actual count. Total catch records exceeded the actual counts by 22 percent during 1947, but in the succeeding years catch records improved and the yearly totals varied less than 3 percent from the true catch. The wide difference between actual and reported totals for 1947 is a result of the long period of inactivity necessitated by World War II. Following the war sportfishing reached greater proportions than ever before. In 1936, 266 boats were registered for party fishing; in 1947, 678; in 1951, 1,051. Many new people became associated with the sportfishing industry. The new boat operators were not aware of the requirement or the use of accurate records and did not devote enough effort to filling them out. Through the contacts made during the checks the boat operators were given a better understanding of the purpose of the records. The result was that boat personnel, in general, presented better catch figures following 1947.

The catch of the California marine sport fishery is composed of more than 20 species. Each of these species falls into one of the four main groups. There is a small degree of overlapping between groups, but the classification is valid for this discussion. The arbitrary grouping is shown in Table 1.

Group 1 includes the very desirable, much sought after game fish. They are seldom caught in large numbers and boat operators keep close track of the catch and reports of these species are reasonably accurate. Group 2 is composed of slightly less popular game fish. Several factors tend to affect the boat records of group 2 fishes; size of fish, localized common names such as "blue cod" instead of cabezon, and heavy catches, as those of barracuda and kelp bass. The rockfishes which comprise group 3 are confined chiefly to the coastline north of Port Conception, and nor-

TABLE 1

Actual Count of Fish by Species Compared to Number Reported on Sportfishing Boat Records

Species	1947			1948			1949		
	Actual count	Boat report	Percent of actual count	Actual count	Boat report	Percent of actual count	Actual count	Boat report	Percent of actual count
Group 1									
Albacore	55	54	98.18	60	62	103.33	36	36	100.00
Lingcod	13	11	84.61	67	66	98.50	75	73	97.33
Salmon									
Yellowtail	10	15	150.0	137	148	108.02	19	26	136.84
Group 2									
Barracuda	3,919	5,300	135.23	1,189	1,259	105.88	1,353	1,291	95.41
Bass, kelp and sand	3,867	5,138	132.86	1,695	1,866	110.08	4,928	4,888	99.18
Cabezon	9	5	55.55	101	91	90.09	55	72	130.90
Halibut, California	260	152	58.46	483	506	104.76	364	380	104.39
Seabass, white	95	99	104.21	31	34	109.67	129	137	106.20
Group 3									
Rockfish	183	170	92.89	1,586	1,302	82.09	2,904	2,443	84.12
Group 4									
Croaker, white (kingfish)	74	10	13.51	384	458	119.27	166	458	275.90
Flatfish	28	20	71.42	78	53	67.94	140	98	70.00
Mackerel, Pacific	1,173	1,032	87.97	635	565	88.97	238	212	89.07
Sculpin	47	42	89.36	252	256	101.58	143	189	132.16
Sheep-head	46	39	84.78	59	58	98.30	80	80	100.00
Whitefish, ocean	22	12	54.54	34	19	55.88	52	66	126.92
Other species	291	180	61.85	215	199	92.55	137	98	71.53
Totals	10,092	12,279	121.67	7,006	6,942	99.08	10,819	10,547	97.48
Total number of anglers checked	2,403			2,223			2,427		

TABLE 1—Continued
Actual Count of Fish by Species Compared to Number Reported on Sportfishing Boat Records

Species	1950			1951			1947-51 total		
	Actual count	Boat report	Percent of actual count	Actual count	Boat report	Percent of actual count	Actual count	Boat report	Percent of actual count
Group 1									
Albacore	354	355	100.28	3	3	100.00	508	510	100.39
Lingcod	152	143	94.07	100	100	100.00	407	393	96.56
Salmon	35	38	108.57	232	239	103.01	267	277	103.74
Yellowtail	13	11	84.61	50	53	106.00	229	253	110.48
Group 2									
Barracuda	1,644	1,906	115.93	84	89	105.95	8,189	9,845	120.22
Bass, kelp and sand	2,715	2,490	91.71	2,632	2,770	105.24	15,837	17,152	108.40
Cabezon	55	52	94.54	125	85	68.00	345	305	88.40
Halibut, California	90	66	73.33	173	184	106.35	1,370	1,288	94.01
Seabass, white	428	506	118.22	7	9	128.57	690	785	113.76
Group 3									
Rockfish	3,589	3,567	99.38	3,389	3,212	94.77	11,651	10,694	91.78
Group 4									
Croaker, white (kingfish)	202	202	100.00	162	339	209.25	988	1,467	148.48
Flatfish	129	86	66.66	898	752	83.74	1,273	1,009	79.26
Mackerel, Pacific	301	261	86.71	27	68	251.85	2,374	2,138	90.05
Sculpin	94	95	101.06	97	80	82.47	633	662	104.58
Sheep-head	43	44	102.32	67	95	141.79	295	316	107.11
Whitefish, ocean	15	18	120.00	8	8	100.00	131	123	93.89
Other species	112	88	78.57	218	96	44.03	973	661	67.93
Totals	9,971	9,928	99.56	8,272	8,182	98.91	46,160	47,878	103.72
Total number of anglers checked	2,357			1,814			11,224		

mally form most of the day's catch in this large area. The species within group 3 are often taken in numbers in excess of the legal allowance, and some boat skippers are prompted to fill out catch records with a total no greater than the legal limit. This results in a reported catch which is less than the actual. Group 4 is made up of fish relatively unimportant to the angler. These fishes are usually caught incidentally and at times may not be identified or counted. One of the species in group 4 is caught in great numbers, the white croaker or kingfish, but is usually discarded or thrown back into the sea. In this case, the estimated amount entered on the record far exceeds the number seen during the boat check.

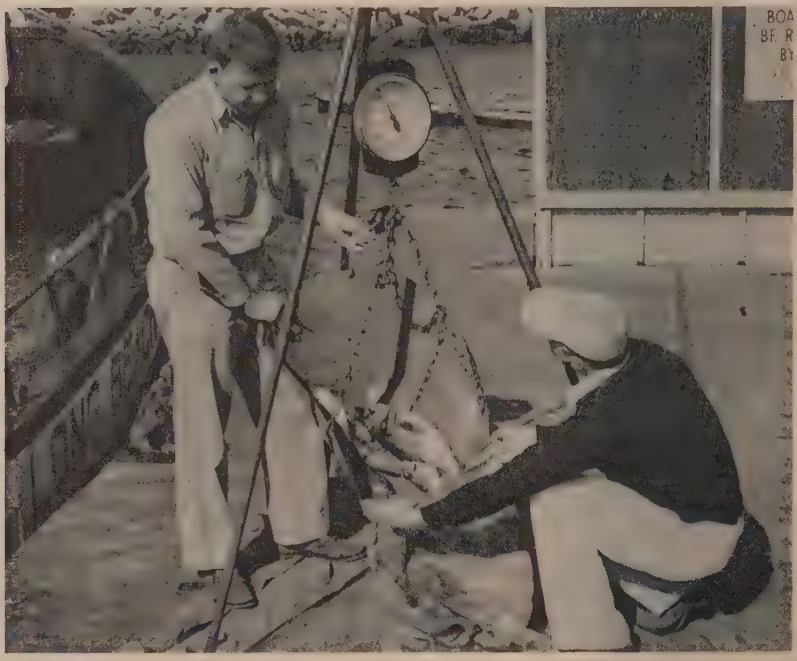

FIGURE 4. Scales and tripod used for sportfishing boat catch checks.

When the season's boat checks were summarized and compared with the operators' reports it was found that the magnifications reported by some operators were compensated by the minimizations of others. Further, boat reports for group 1 were relatively accurate. Boat reports for group 2 offset group 3. Component species of group 4, when added together gave a surprisingly accurate total. It is fortunate that the boat record totals can be expected to so closely approximate the actual totals. Summaries that included all species do not have biological value, but do furnish a guide as to the over-all condition of the marine sport fishery. The checks also indicate that the records since 1947 have been satisfactorily accurate for the individual species of group 1 and relatively so for those of group 2.

The percentage of boat operators keeping records increased during the five years. Table 2 shows the number of boat record checks made by port of landing and also the percentage of boat operators who had not kept a record for the day their catch was counted. In 1947, 17.9 percent of the 112 boat operators checked did not have the day's record made out when checked. In 1951, only 3.9 percent of 102 checked failed to have their record made out on time.

All fish in addition to being counted were also weighed to the nearest ¼-pound. Records so obtained showed that the recorded weights were generally very different from the actual poundages landed and it has not been practical to require the boat crew to keep an accurate record of the poundage of fish caught. A reasonable estimate is acceptable.

From the figures obtained from the weighing procedure, the average weight by species was determined. Table 3 shows the average weight per fish for some of the more important sport species. These averages are on a state-wide basis. Between areas, the average weight for a single species often varies.

The catch per angler as derived from the sport boat checks indicates variations in fishing success from port to port (Table 4). Most of the areas were visited each year. The catch per angler day was obtained by dividing the number of fish counted by the number of fishermen landing the catch. The principal species of fish taken in each area are also listed in Table 4.

TABLE 2

Number of Party Boats Checked by Port by Year

Port	1947	1948	1949	1950	1951	Total
Berkeley				7	16	23
Sausalito					4	4
San Francisco					9	9
Princeton		4	9	13	9	35
Santa Cruz				4	3	7
Capitola				1		1
Monterey		4	3	12	4	23
Cayucos	3	3	2		4	12
Morro Bay		3	5	7	5	20
Avila		6	4		2	12
Ventura	1					1
Port Hueneme		1	14	9	1	25
Malibu	4		2		3	9
Santa Monica	7	5	6		4	22
Ocean Park	2	3	2	2		9
Redondo Beach	9	5	3	2	6	25
San Pedro	18	11	15	8	6	58
Wilmington		4		9	1	14
Long Beach	16	11	13	11	6	57
Seal Beach	7	5	2	1	1	16
Newport Beach	32	36	29	25	12	134
San Clemente	4	5	4			13
Oceanside	2	7	2	2		13
San Diego	7	24	1	7	6	45
Totals	112	137	116	120	102	587
Number of boats with no record	20	9	8	3	4	43
Percentage of boats with no record	17.9	6.6	7.1	2.5	3.9	7.3

TABLE 3

Average Weight by Species

Figures From Sportfishing Boat Checks, 1947-1951—Round Fish Only

Species	Number of fish weighed	Total weight, pounds	Average weight, pounds
Albacore	136	2,501	18.4
Barracuda	2,836	13,896	4.9
Bass, kelp and sand	7,285	9,057.75	1.2
Cabezon	378	1,893.25	5.0
Croaker, white (kingfish)	974	546	0.6
Halibut, California	976	3,880.50	4.0
Lingcod	480	3,167.75	8.7
Rockfish	11,347	18,018.75	1.6
Seabass, white	196	1,526.50	7.8
Sheep-head	157	485.75	3.1
Sculpin	362	478.75	1.3
Sanddab	390	100.50	0.3

TABLE 4

Party Boat Checks, 1947-1951, Catch per Angler Day, by Port of Landing, All Species

	Number of fish counted	Number of angler days	Catch per angler day	Principal species taken in area
San Francisco Bay	346	297	1.2	Salmon
Princeton	3,574	577	6.2	Rockfish, lingcod, flatfish
Santa Cruz	1,446	294	4.9	Rockfish, lingcod, flatfish
Monterey	2,868	315	9.1	Rockfish, lingcod, flatfish
Cayucos, Morro Bay	2,590	454	5.7	Rockfish, flatfish, cabezon
Avila	1,151	203	5.7	Rockfish, cabezon, flatfish
Port Hueneme	1,862	417	4.5	Kelp bass, rockfish, halibut
Malibu	915	244	3.8	Kelp bass, rockfish, halibut
Santa Monica-Ocean Park	1,419	432	3.3	Kelp bass, halibut, barracuda
Redondo Beach	2,683	465	5.8	Kelp bass, rockfish, halibut
Los Angeles Harbor	14,312	3,203	4.5	Kelp bass, barracuda, rockfish
Newport Beach	7,503	1,886	4.0	Kelp bass, barracuda, albacore
San Clemente	1,786	350	5.1	Kelp bass, barracuda, white seabass
Oceanside	2,265	304	7.5	Kelp bass, barracuda, white seabass
San Diego	2,541	808	3.1	Kelp bass, barracuda, yellowtail
Totals, state wide	47,261	10,249	4.6	

DISCUSSION

From the data available, it can be said that sport catch records have improved in quantity and quality. The records of total numbers of fish landed appear to be accurate. There has been some increase in the accuracy of individual species reports; however, further improvement is necessary. The sport catch reports of the important game fishes are accurate enough to fulfill the purposes for which they are intended.

To improve the catch record system further, constant field work will be necessary. Maintenance of the interest and the support of sport boat personnel is of primary importance.

ACKNOWLEDGMENTS

This report, although short in form, covers work which demanded a great deal in the way of time and cooperation from many persons. Within the Department of Fish and Game, R. D. Collyer provided the incentive and ambition to launch the sport boat check system, and was present for all individual boat checks, save a few. The marine patrol staff from San Diego to Eureka provided all the aid and advice that could be desired. The cooperation from landing operators and boatmen has been excellent, even though some were of the opinion that boat checks were an unnecessary evil. Fishermen were mainly cooperative, but an occasional one would object rather strenuously. Unfortunately these objectors comprised a high percentage of individuals with no license and with overlimit catches. Many of the members of the staff of the Marine Fisheries Branch, Department of Fish and Game, were helpful with suggestions and in participating in the boat checks. To all of these people we extend our sincere thanks.

TABLE 5

List of Common and Scientific Names

Common name	Scientific name
Albacore	*Thunnus germo*
Barracuda	*Sphyraena argentea*
Bass, kelp	*Paralabrax clathratus*
Bass, sand	*Paralabrax nebulifer*
Cabezon	*Scorpaenichthys marmoratus*
Croaker, white (kingfish)	*Genyonemus lineatus*
Flatfish	Various Pleuronectids and Bothids
Halibut, California	*Paralichthys californicus*
Lingcod	*Ophiodon elongatus*
Mackerel, Pacific	*Pneumatophorus diego*
Rockfish	Species of *Sebastodes*
Salmon	Species of *Oncorhynchus*
Sanddab	Species of *Citharichthys*
Sculpin	*Scorpaena guttata*
Seabass, white	*Cynoscion nobilis*
Sheep-head	*Pimelometopon pulchrum*
Whitefish, ocean	*Caulolatilus princeps*
Yellowtail	*Seriola dorsalis*

THE USE OF LARVAL AND ADULT BRINE SHRIMP IN AQUARIUM FISH CULTURE[1]

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INTRODUCTION

One of the most urgent problems confronting biologists and fish fanciers who are interested in raising fish or other aquatic animals is to obtain live food. Larval and adult brine shrimp of the genus *Artemia* offer a practical solution to this problem. They are ideal as natural food for larval fishes and other young aquatic vertebrates (Seale, 1933).

Many biologists who visit Steinhart Aquarium inquire about brine shrimp and the best methods for their culture. Because of these inquiries it was suggested to the writer that a paper be prepared presenting the latest information on the use of this important organism in fish cultural practices.

BIOLOGICAL NOTES

The brine shrimp are crustaceans belonging to the order Phyllopoda. These leaf-footed animals, as the term Phyllopoda signifies, may usually be found in great abundance in natural salt lakes and alkaline lakes throughout the world. They abound in water of high salinity. Artificial salt ponds (Figure 1) where sea water is being evaporated for the purpose of obtaining salt, are usually teeming with them. Kellogg (1906) listed four American species of *Artemia: A. gracilis* Verrill, found in barrels of salt-marsh water (density of 1.060-1.065) exposed on a railroad bridge near New Haven, Connecticut; *A. fertilis* Verrill, of Great Salt Lake (density 1.17); *A. monica* Verrill, found in Mono Lake, California, which is a strongly alkaline and salt lake in the Owens River desert; and *A. franciscanus* Kellogg, found in the evaporating pools (density 1.09 to above 1.20) of salt works in Redwood City, California. Relyea (1937) considered *Artemia gracilis* to be the species of brine shrimp inhabiting Great Salt Lake. The species of brine shrimp commonly found in the salt ponds in California is now generally considered to be *Artemia salina.*

Brine shrimp may reproduce either by parthenogenesis or by a sexual process. If only females are present, the eggs will develop without fertilization (Relyea, 1937). When mature males and females are present, copulation takes place (Figure 2) and the eggs are fertilized within the reproductive tract of the female. The eggs of an oviferous female are retained in the ovisac until a tough chitinous shell has formed around each one of them. The fully matured eggs are then deposited in the water where they will hatch if conditions are favorable.

[1] Submitted for publication December, 1952.

FIGURE 1. Collecting brine shrimp in the salt ponds near Redwood City, California. Photograph by K. F. Innes, August, 1952.

FIGURE 2. Male and female brine shrimp copulating. Magnified 3½ times. Photographed by F. L. Rogers, November, 1951.

These eggs appear to be extremely resistant to adverse environmental conditions. The temperature may drop to the freezing point without destroying the germ cell (Whitaker, 1940). The eggs may become desiccated, and even though they remain in that state for many years they will hatch if submerged in salt water of a correct salinity and temperature inducive to hatching. If the female deposits her eggs in sea water which has a specific gravity of 1.09 or higher, they will float on the surface and will not hatch but may be blown by the wind or be carried by water currents to the beaches, where they remain until the rains wash them back into the water (Figure 3). The rains tend to dilute the

FIGURE 3. The author, left, and Maurice Rakowicz collecting and examining brine shrimp eggs that have washed up on the beach at one of the salt ponds near Redwood City, California. Photograph by K. F. Innes, August, 1952.

surface water and when the eggs come in contact with it they usually hatch, provided the specific gravity of this water is less than 1.09 and the temperature is higher than 9 degrees C.

In many instances the eggs actually hatch within the ovisac of the female, and the embryos develop into nauplii before they are born. A large female may give birth to as many as 200 nauplii within a period of a few minutes. It is interesting to observe the manner in which the young are born. They are kept in motion within the ovisac by spastic movements of the muscles surrounding it, and suddenly when birth is about to take place, some of the nauplii are released from the others and are moved toward a funnel-shaped aperture in the ovisac. After a few convulsive movements of the funnel muscles, the aperture opens and the nauplii are forcefully ejected into the water.

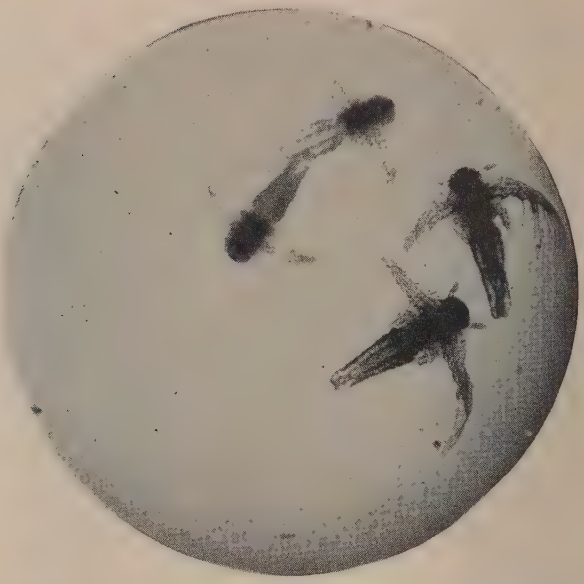

FIGURE 4. Brine shrimp nauplii a few hours after hatching, magnified 25 times. The large oarlike appendages are used as swimming organs. Photograph by F. L. Rogers, November, 1951.

Jensen (1918) has given a good account of the life history of the Salt Lake brine shrimp, *Artemia gracilis*. The nauplius is of a blood-red color, has a median ocellus and three pairs of appendages (Figure 4). The first pair of appendages develop into the first pair of antennae; the second pair, which are much larger and serve as swimming organs, become the second pair of antennae, and the third pair become the mandibles. In females the second pair of antennae are small, scarcely movable processes, whereas in males the second pair are disproportionately large, are broad lobed, and are used as catching and clasping organs (Figure 5). Segmentation occurs early in the development of the nauplius, and is followed by the appearance of the stalked compound eyes and the thoracic appendages. Each pair of appendages develops consecutively until all 11 pairs have been laid down. Brine shrimp reach sexual maturity within 18 to 21 days after they hatch. Sexual differences become apparent when the animals are a little more than half grown. The males are stronger and more active than the females, adult males averaging 10 mm. in length and females 10 to 12 mm.

According to Relyea (1937), Schmankewitch some years ago experimented with the *Artemia* of some salt pools near Odessa, Russia. He believed that *Artemia* changed its form according to the salt content of the water in which it lived. He also found that, during warm weather, only females were produced and that males were present only in water of medium salt concentration. Relyea also stated that, according to Gilbert, *Artemia* was a freshwater phyllopod before Lake Bonneville, which was originally a freshwater lake, became the Great Salt Lake. Kellogg found that brine shrimp living in pools with a density of 1.110-1.113

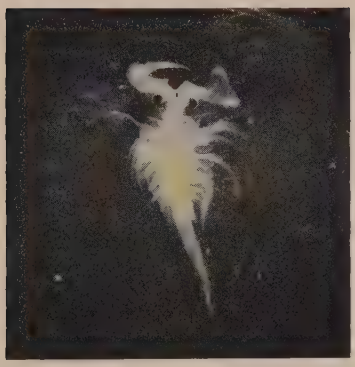

FIGURE 5. Mature male brine shrimp showing the large claspers on the head region. Photograph by F. L. Rogers, November, 1951.

were whitish, large, active and abundant; those in densities above 1.20 were reddish, small, less active and fewer in number. Relyea stated that the adult brine shrimp of Great Salt Lake die off when the water temperature falls below 6 degrees C. The winter eggs are not adversely affected by low temperatures and live on until spring, when they hatch in great numbers.

PROCESSING OF *ARTEMIA* EGGS

Fish fanciers and biologists take advantage of the fact that the eggs may become dry without injury to the germ cell. The dry eggs may be conveniently stored and used only as the need for them arises. When they are put into warm salt water they hatch within a few hours into minute free-swimming nauplii which make excellent food for young fish.

Freshly collected, unprocessed eggs (Figure 6) are usually foul smelling and, to the inexperienced eye, look like nothing but brown mud. In a bucket of this material there will be millions of small, round, brown eggs, each one being about 0.2 mm. in diameter (Figure 7). After the eggs have been collected they must be washed with fresh water and separated from the foreign matter that invariably accompanies them. This is accomplished by washing them through a series of screens, beginning with one of coarse mesh and finishing with one of fine mesh. After the eggs are clean and the water has had time to drain off, they are transferred to a warm room, where they are spread out in a thin layer on trays to dry. After the eggs have once been exposed to fresh water they must be dried as quickly as possible, because they will spoil if they are allowed to remain in a warm damp condition for very long. They should be dried in 24 hours or less. After the eggs have become thoroughly dry, they are sifted through a fine-mesh screen and then tested.

FIGURE 6. Freshly collected eggs showing the debris that usually accompanies them. Photograph by K. F. Innes, August, 1952.

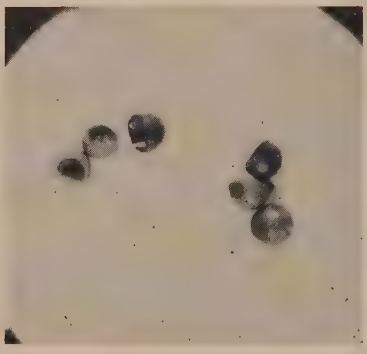

FIGURE 7. Brine shrimp eggs magnified 50 times. Note that they are concave on one side. This is characteristic of all dry brine shrimp eggs. When they are submerged in salt water they become round. Photograph by F. L. Rogers, November, 1952.

TESTING OF *ARTEMIA* EGGS

Eggs are tested by the following method: Five samples, each containing six cc. of eggs, are selected from a collection and set up in three-gallon glass battery jars containing ordinary sea water at a temperature of approximately 75 degrees F. (Dempster, 1946). The water is gently aerated and after a period of 48 hours the newly hatched nauplii are siphoned into a fine-mesh silk net. The nauplii, egg shells, etc., that collect in the net are washed with a stream of fresh water into a beaker and then transferred to a tall graduate and allowed to stand for 10 minutes. At the end of this time the small amount of heavy residue and unhatched eggs which is usually present has settled on the bottom and the egg shells float at the surface, whereas the nauplii occupy the area between the floating egg shells and the residue. The nauplii are then siphoned into a separatory funnel and killed with formaldehyde. After they have concentrated on the bottom of the funnel they are drained into a small graduate and allowed to settle for one hour. The volume of settled nauplii is then recorded. The volume of nauplii hatching from a given volume of eggs set up in a culture may be determined within 0.1 cc. by this method.

The quality of the eggs may be determined in the field with some degree of accuracy by simply putting a few of them in a container of fresh water and observing whether they float or sink. If the majority of them float, the collection may be considered as poor, and if most of them settle on the bottom, the collection may be considered to be good.

Through experience, the writer found that eggs of highest quality were consistently heavier per unit volume than those of low quality; i.e., when two carefully weighed samples, each containing the same volume of eggs, were set up side by side in cultures under identical conditions, the heavier sample always produced more shrimp than the lighter sample. Since the heavier samples produced more shrimp than the lighter samples, it was assumed that the heavy eggs were fertile and the light ones were not.

SEPARATING *ARTEMIA* EGGS

Considerable thought was given to the problem of separating the heavy eggs from the light ones because of the desirability of having a pure culture of heavy eggs—and thereby establishing a quality standard for brine shrimp eggs. It was hoped that, by taking advantage of a differential in weight, the light eggs could be separated from the heavy (or fertile) ones by the use of air currents.

At first the eggs were separated by means of a flume and an electric fan (Dempster, 1946). The flume was eight feet long, 11 inches wide, and 10 inches deep. Low partitions or bins were installed inside at intervals of about one foot, and a small fan was placed at one end. The flume lay horizontal to the floor. When the fan was put in motion, eggs were poured slowly through a slot immediately in front of the fan, where they were blown along the flume. The principle of this method was that the heavy eggs would fall into the bins and the shells would be blown out of the end of the flume. This method did not work satisfactorily. The eggs were not well separated and the whole process required too much attention.

Another method works much better. The equipment used is a vacuum sweeper (reversed to act as a blower) and three lengths of ordinary stovepipe with a few fittings. The lengths of pipe are sealed together, forming a tube six inches in diameter and six feet high. A plug, which serves as a base for the tube, is soldered to one end, and near this end in one side is inserted an elbow placed so as to point downward into the tube. The blower is connected to this elbow by a hose and a short piece of pipe. A valve is placed between the blower and the tube to control the volume of air directed on the eggs (Figure 8). Eggs that

FIGURE 8 Brine shrimp egg separator in action. The egg shells are being blown out the top of the tube. In the average collection of eggs, about 25 percent is shells. Photograph by F. S. Rogers, November, 1951.

are about to be separated are poured into the top of the tube. After they have settled on the bottom, the blower is turned on and air which is forced into the bottom of the tube agitates the eggs quite vigorously and blows the light ones out of the open end. After a short period, the light eggs will have blown out and only the heavy eggs will remain.

These in turn may be poured off into a suitable container for storage. It takes about 20 minutes to separate a gallon of eggs by this method. Not more than one gallon should be separated at one time.

Brine shrimp eggs cling together very tenaciously when they have become dry. Even though they are sifted through a moderately fine-mesh screen (32 meshes to the inch) they come through in clusters which resemble miniature bunches of grapes. Since clusters consist of heavy eggs and light eggs in all proportions, adhering tightly together, an accurate separation cannot possibly be effected with the blower unless these clusters are broken up.

After experimenting with several grades of wire screens, it was found that one with 60 meshes to the inch worked most satisfactorily. A screen of this grade allows only single eggs or, at most, clusters of two or three to go through. Eggs treated in this manner are readily separated with the blower. When a sample of the material that blows out of the separator is set up in a culture, no hatch results. This material, when observed under a microscope, is found to consist of infertile eggs and egg shells.

HOW TO HATCH *ARTEMIA* EGGS

The type of container most commonly used for egg hatching is an enameled pan or glass ovenware dish with a capacity of two or three quarts. A wooden partition should be placed in each container, about four inches from one end. It should extend about one-half inch above the surface of the water and have one-fourth inch clearance between its bottom edge and the bottom of the container. If ordinary seawater is not available, a very satisfactory medium for the culture may be made by adding six tablespoons of noniodized table salt or rock salt to each gallon of fresh water (Von Hein, 1950). The temperature of the solution should be about 75 degrees F. (23.89 C.). To each two quarts of this water which has been poured into the pans, add one-quarter teaspoon of eggs and allow the culture to remain undisturbed for 48 hours. The eggs should be put in the smaller of the two areas blocked off by the partition. After 48 hours the majority of the eggs will have hatched and the baby shrimp are ready for use. In normal practice, two or more pans are set up and the cultures staggered so that newly hatched shrimp are available every day for feeding. These organisms are positively phototrophic (Keliherer, 1948) so as soon as they hatch they leave the darkened area created by floating eggs, and swim under the partition toward the lighter area in the container, where they will congregate in large numbers. They may then be readily siphoned out and the unhatched eggs and egg shells will be left in the pan.

It is not advisable to put egg shells or unhatched eggs in a tank where tiny fish or other aquatic animals are being raised. The eggs may be eaten and, since they are quite indigestible, they may pass through the stomach, lodge in the intestine, and thus block the opening. Many baby pipefish and walleyed pike that the author attempted to raise have died because this very thing happened.

Both brine shrimp and brine shrimp eggs are so much esteemed as a well-rounded dietary item for freshwater fishes, marine fishes, and other aquatic animals, that their use has become world-wide. The San

Francisco Aquarium Society, a nonprofit organization, is the focal center for the production and distribution of this very desirable fish food.

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THE REMOVAL OF ABANDONED DAMS IN THE UPPER KLAMATH RIVER DRAINAGE, CALIFORNIA[1]

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During the past 80 or 90 years, many dams were built in the Klamath River drainage in Trinity and Siskiyou Counties. Their purpose was to divert water for domestic and mining uses. Some of these were small, lightly built structures for temporary use, and were short-lived in the rushing torrents of the annual spring runoff. Others, built for long-term mining diversion, were constructed of heavy logs and cribbed for strength. Fish were abundant, and little thought was given to the effects of these dams on salmon or steelhead.[2] All of the dams formed partial or complete obstructions to migrant fish on their spawning runs, cutting off all of the nursery gravels above and confining the fish to the sections below the dams.

EFFECT ON FISH

Over a period of years the runs of fish into the streams with dams were reduced to numbers consistent with the spawning area available. There would be no fish above the dams unless a stock of resident trout were present, or those portions of the streams were stocked from the state fish hatcheries. In addition to curtailing the runs of fish in the streams on which the dams were located, the runs of steelhead and salmon in the main rivers were, of course, reduced. In the ocean the numbers of salmon available to the commercial fishery were restricted by this reduction in spawning area.

FISH LADDERS

Under California law, when the Fish and Game Commission deems that the construction of a fishway over a dam is necessary for the preservation and protection of fish, and that construction and operation of such fishway is practicable, the owner of the dam is responsible for the installation of the fishway in accordance with the specifications of the commission and must keep it in repair and open and free from obstructions to the passage of fish at all times.

Over 50 years ago the California Fish and Game Commission requested the owners of the larger dams, which were obviously stopping good runs of fish, to build ladders over them. This conservation trend received more attention as time went on and eventually nearly all known dams were equipped with fish ladders. No doubt these early attempts to get

[1] Submitted for publication January, 1953.
[2] The principal species of anadromous salmonids in the Klamath River drainage are king salmon (*Oncorhynchus tshawytscha*), silver salmon (*O. kisutch*), and steelhead rainbow trout (*Salmo gairdneri gairdneri*).

fish over dams were sincere, but in the light of more recent experience we believe that many of the older ladders did not function satisfactorily. Two of the most notable examples of such ladders were the ones over the lower Canyon Creek dam in Trinity County and the Bennett-Smith dam on the South Fork of the Salmon River in Siskiyou County.

Nearly all of the dams were old, wooden structures and the ladders themselves were of wood. Such wooden ladders were, of course, vulnerable to the pounding of water and debris going over the dam in times of flood, and as a result were often damaged and useless to the fish when they were most essential. As the wooden ladders advanced in age it often became necessary to repair them almost annually. Whether or not these repairs were made depended upon the pressure applied by the Department (then Division) of Fish and Game. As a whole, the situation continued to worsen and the runs of fish suffered seriously. Had the dams originally been built of concrete with good, almost indestructible ladders, many of them would not have been greatly harmful to migrant fish. Under the circumstances just described, however, it became desirable to remove all such dams which were not absolutely needed. Certainly, it would have been inadvisable to install modern concrete ladders costing anywhere from $10,000 to $30,000 on old, rotting, log dams which were holdovers from mining days.

LEGAL DIFFICULTIES

The problem of removing these ancient, abandoned dams was most difficult, since permission in writing had to be obtained from the owners. Most of the dams causing trouble had been built by mining men who had moved away after the claims had played out. In the case of three of the larger dams, local caretakers had been appointed to see that the dams were preserved in the event it was decided to put the diversions to use at some future time.

From the legal viewpoint, it was only necessary to maintain the fish ladders in a reasonably good condition to prevent action by the State. In some cases, the ditches carrying water from these old dams furnished a convenient source of water for people living downstream. These parties owned no parts of the dams themselves, but did have riparian rights on the creeks. These people were willing to assist with repairs needed on the fish ladders in order to furnish legal reason for preserving the dams. In this way they received water without the expense of providing their own diversion dams. These individuals were seriously affecting the entire runs of steelhead and salmon, which belonged to all of the people of the State of California.

Fortunately, there was one legal way to put an end to all this controversy. It was only necessary to secure written permission from the actual owners stating that they had no further use for the dam and that the State could remove it. This was not always as simple as it might seem. In some cases the mining companies had been dissolved for years and the owners had either died or scattered to distant places. An attorney who was asked for an opinion regarding one dam which did not even have a fish ladder put it this way. "A dam is like a home or any other personal property. It cannot be removed without the permission of the owner.

This is true even if the dam has no fish ladder. The owner must still be contacted and given a choice of building a fish ladder or granting permission for removal."

The State has had to write dam owners living as far east as New York and as far west as the island of Okinawa. The correspondence and litigation often made these removals very difficult, but in no case did the State fail to obtain final permission. At two larger dams in Trinity County, one on Canyon Creek and the other on the North Fork of the Trinity River, the owners for many years refused to grant permission

FIGURE 1. Abandoned dams removed in Siskiyou and Trinity Counties.

for removal and persisted in repairing old wooden fish ladders until at last the ladders became so rotten and expensive to maintain that permission was finally granted and the dams were either breached or completely removed by the State.

WORK IN TRINITY COUNTY

At the present time, the prospect of migrant fish ascending the major streams in Trinity County is much improved. The efforts to clear the streams of these obstructions have been continuing for 30 years. Fish and Game deputies G. O. Laws and R. C. Marshall, working in cooperation with the former State Bureau of Hydraulics or Engineering scored initial successes back in the twenties by enforcing fish ladder laws and in helping with the actual dam removal. In later years, Fish and Game Warden Claude Gourley, of Weaverville, gave assistance to members of the Bureau of Fish Conservation who actively carried on the work.

The physical task of reaching and removing the dams has not always been an easy one. The miners who built these dams were a breed of men not easily turned aside by inaccessibility and at least two of their dams in Trinity County were far from the beaten path. One of these was in a lonely spot nearly five miles by trail from the nearest road. The other was reached by two miles of steep trail in the rugged canyon of the North Fork.

Despite the 15 dams in Trinity County which have been listed as removed, plus an indefinite number removed even prior to 1920, we still have 12 known dams remaining in Trinity County streams. Four of these are equipped with fish ladders and a fifth one will have a ladder in the near future. The remaining seven dams without ladders are either too low to form real obstructions or are located too near stream headwaters to merit the expense of a ladder, in view of the short and rocky length of stream above them.

A short study of Figure 1 should make it quite clear that impassable dams effectively strangled the spawning potential of many of the tributary streams in the Trinity River drainage for perhaps half a century. An exact tabulation of the miles of spawning gravel opened up to fish by removal of these dams would be impossible without considerably more field study than has been expended. A conservative estimate, however, shows that we have gained approximately 110 miles of suitable steelhead stream by the removal of 15 dams in Trinity County alone.

WORK IN SISKIYOU COUNTY

In Siskiyou County the history of abandoned dam removal has closely paralleled that in Trinity County. Seven dams have been removed by personnel of the Stream Improvement Headquarters in Yreka. In addition, two dams are known to have been washed out by floods in recent years. Although no special study has been made to determine the amount of spawning gravel opened up by removal of these dams, it has been estimated conservatively at 100 miles. Thus, in the Klamath drainage lying in Trinity and Siskiyou Counties alone 22 dams have been removed in the past few years. These removals plus the two dams in Siskiyou County which recently washed out have added at least 210 miles to the area available for steelhead and salmon spawning. This conservation

work has been surprisingly inexpensive. A rough estimate of the cost to the State in both counties is $3,000. At present the Klamath drainage is probably about as free of obstructions to migrating fish as it has been in the past 100 years, with the one important exception of the Copco power dams on the main Klamath River. These latter dams cut off a most important segment of the spawning area of the drainage.

TRINITY COUNTY DAMS WHICH HAVE BEEN REMOVED

The following list of removed dams is not a complete one, since many old dams in Trinity County have disappeared without record. A few other old dams were known by name as having existed, but location and removal circumstances were too sketchy to list here. In some instances dams were removed by unknown parties without the owner's permission.

Salt Creek Dam, Tributary to Hayfork Creek

This log dam, 10 feet high, was located on Salt Creek, a tributary of Hayfork Creek. It was removed with the help of the county supervisors.

Russell or Hinkley Dam, Hayfork Creek

This 11-foot log dam was blasted out by Fish and Game Warden G. O. Laws about 1922.

Hessellwood Dam, Hayfork Creek

This 10-foot log dam was dynamited by order of the Fish and Game Commission in 1925, after the owners had repeatedly postponed construction of a fish ladder.

FIGURE 2. The abandoned North Fork Placers dam on the North Fork of the Trinity River. Showing fishway blasted through one wing. *Photograph by John Handley, August 29, 1950.*

FIGURE 3. Abandoned mining dam on Canyon Creek, Trinity County. Bulldozer had just started to remove topping so that a cable could be attached to larger stringers and these pulled to a point above the stream's high water mark. *Photograph by J. H. Wales, October 9, 1951.*

Big Creek Manufacturing or Mining Company Dam, Big Creek

This dam was located on Big Creek, a tributary of Hayfork Creek, near the town of Hayfork. It was 14 feet high and of log construction. The date of removal by the Fish and Game Commission is uncertain.

Lone Jack Dam, East Fork of North Fork of Trinity River

This log dam, 24 feet high was dynamited out by the owners, who no longer used it and did not want to build a fish ladder.

Henry Danninbrink Dam, Canyon Creek

This dam, the height of which is unknown, was removed by the owners in 1927 to avoid building a fish ladder.

Anderline Dam, Rush Creek

This dam was located on Rush Creek, a tributary of the Trinity River, near Lewiston. It was 20 feet high and of log construction. In 1936 it was removed by parties unknown.

Trinity County Water and Power Company Dam, East Fork of Trinity River

This dam was about 10 feet high and of masonry construction. It was removed by the Yreka Stream Improvement Crew on August 30, 1946.

FIGURE 4. Canyon Creek, Trinity County, after dam shown in Figure 3 had been removed. Men are standing on the line of the face of the former dam. The stream has cut down through part of the gravel deposited behind the dam. *Photograph by J. H. Wales, October 13, 1951.*

D. B. Fields Dam, Indian Creek

This six-foot dam of log construction was removed by the Yreka Stream Improvement Crew on February 19, 1947.

D. B. Fields or Johnson Dam, South Fork of Indian Creek

This 10-foot dam of log construction was breached by parties unknown about 1946.

Todd Dam, East Fork of North Fork of Trinity River

The Yreka Stream Improvement Crew removed this 14-foot log dam on October 4, 1949.

Clarrissa V. Mining Dam, Redding Creek

This was another log dam about 20 feet high. It was partially removed with dynamite by parties unknown. On July 11, 1950, the Yreka Stream Improvement Crew completed the job and made the stream accessible to salmon and steelhead.

North Fork Placers Dam, North Fork of Trinity River

A wing of this 15-foot log dam was breached by the Yreka Stream Improvement Crew on August 29, 1950.

Quinn Dam, East Fork of North Fork of Trinity River

This 14-foot log dam was completely blasted out by the Yreka Stream Improvement Crew on January 2, 1951.

Red Hill Mining Company Dam, Canyon Creek

This log dam was 30 feet high. It was constructed a great many years ago for a mining diversion and even though it had a wooden ladder it was a complete barrier. The correspondence relating to this dam and fish ladder extends over a period of nearly 40 years. Written permission to remove the dam was finally obtained from the owners and the demolition was completed on October 12, 1951.

SISKIYOU COUNTY DAMS WHICH HAVE BEEN REMOVED

FIGURE 5. Bonally dam, North Fork of the Salmon. River, Siskiyou County. This abandoned mining dam was completely removed by dynamite in 1946. *Photograph by K. Bonham, 1934.*

Bonally Mining Company Dam, North Fork of the Salmon River

The Bonally Mining Company dam was built in 1906 or 1909. This log-crib structure was located about six miles above the mouth of the North Fork of the Salmon River and was 177 feet long and 11 feet high. A wooden fish ladder leading into the flume was constructed in 1914. After an investigation in 1934, Taft and Shapovalov (1935) made the following comments: "The Bonally dam, located approximately six miles above the Forks of the Salmon, is considered by local U. S. Forest officials and by local residents as the most serious obstacle to upstream migrant steelhead and salmon in the North Fork of the Salmon River. It is a crib

dam 11 feet high, no longer in use. The so-called fish ladder is entirely inadequate, as it consists only of the intake and upper portion of the old flume, which is broken down with the idea that fish can pass into it from the rocks below. This 'fish ladder' not only plugs up in the natural manner but is also often plugged up by local inhabitants to secure fish. It would be highly desirable to blast out the dam or at least build an adequate fish ladder.''

The dam was removed by dynamite on October 7, 1946. With subsequent improvement and construction of fish ladders on two dams further upstream by the Yreka Stream Improvement Crew, approximately 31 miles of stream have been opened for migratory fish.

Altoona Dam, Kidder Creek

The Altoona dam was located about six miles from the mouth of Kidder Creek, a tributary of the Scott River. The dam, constructed of heavy logs, was built for mining use and was about 12 feet high and 60 feet long. After securing permission from the owners, this abandoned barrier was blasted out in May, 1947, by the Yreka Stream Improvement Crew. An additional two miles of Kidder Creek was opened up for steelhead and silver salmon spawning.

Big Nugget Mine Dam, Horse Creek

The Big Nugget Mine dam was situated about eight miles upstream from the mouth of Horse Creek, a tributary of the Klamath River. This was a log-crib dam, 12 feet high and 40 feet long. On May 31, 1949, it was completely removed by dynamite, opening up about four miles of stream. On April 29, 1950, a pair of spawning steelhead was observed about two miles above the former dam.

Moser Dam, Swillup Creek

Swillup Creek enters the Klamath River about 15 miles below Happy Camp. The Moser dam, sturdily constructed of concrete and heavy logs, was located about one and one-half miles above the mouth of the creek. Constructed in the 1930's for mining operations, which were later abandoned, it did not have a fish ladder. After permission had been secured from the owner, the dam was breached on August 9, 1949, and later was completely reduced. About two miles of stream were opened to spawning and on March 29, 1950, a pair of steelhead was observed spawning about 100 yards above the remains of the dam.

Smith Dam, White's Gulch

This log dam was located on White's Gulch, a tributary entering the North Fork of the Salmon River about three miles above Sawyers Bar. This barrier was about 8 feet high and 25 feet long. It was blasted out on September 14, 1949. U. S. Forest Service officials at Sawyers Bar report that steelhead now spawn in the section of stream above the old dam.

Three C. Picket Dam, Beaver Creek

On September 21, 1949, a dam near an abandoned CCC camp was removed. This small dam probably did not prevent upstream migration of fish, but could have developed into a log jam.

Barton Dam, South Fork of the Scott River

The Barton dam was situated about four miles above the town of Callahan. Old time residents stated that this abandoned dam was about 50 years old and it was a favorite steelhead poaching site. Permission to remove the dam was obtained from the owner and it was destroyed on February 9, 1950. This dam was about 12 feet high and 25 feet long. Its removal opened an additional four miles to spawning.

Minnie Reeves Dam, Indian Creek

This important old log dam should be mentioned even though it was washed out by a flood and not removed by the Department of Fish and Game. It was about 20 feet high and a complete barrier, since the ladder was never satisfactory. Undoubtedly it had a serious effect upon the salmon and steelhead runs into this excellent stream and its removal has opened up about 18 miles for spawning.

Bennett-Smith Dam, South Fork of the Salmon River

The Bennett-Smith dam, situated about five miles above the confluence of the South Fork and North Fork of the Salmon River, went out in a flood during the last week of October, 1950. This was an abandoned, log dam about 10 feet high and although it had a ladder it was a serious barrier and a poaching spot for many years. Salmon and steelhead are now able to reach some of the finest spawning grounds in the Klamath drainage.

SUMMARY

1. Many sections of streams in the Klamath River drainage in Siskiyou and Trinity Counties have been made accessible to spawning migrations of steelhead and salmon by the removal of abandoned mining dams.
2. Twenty-four dams are described in this article. Twenty-two of these were removed by the California Department of Fish and Game or other interested parties and two were washed out by floods.
3. The removal of these barriers opened up at least 210 miles of good spawning stream at a total cost to the State of approximately $3,000.

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THE RARE CIRRHITID FISH GENUS *OXYCIRRHITES* IN AMERICAN WATERS[1]

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During the spring of 1952 the senior author was privileged to be engaged in ichthyological work on the Sefton-Stanford Expedition to the Gulf of California, aboard the research ship Orca. The expedition was sponsored by Mr. Joseph W. Sefton of San Diego, California, and the majority of the scientific personnel was from Stanford University. Although several collections were made along the outer coast of Baja California, the expedition spent most of its time working among the islands inside the gulf. In one dredge haul off the southern tip of Baja California, a single specimen of a strange fish was taken which entered the field notes as "long-snouted red cross-hatch fish." This specimen proved to be the fourth recorded specimen of the genus *Oxycirrhites*, the first specimen from the New World, and an undescribed species. The three specimens of the genus previously recorded are: Bleeker's holotype of *O. typus* from Amboina (1857, p. 40), a specimen from Mauritius described by Günther (1860, p. 76), and Fowler's holotype of *O. morrisi* from the Philippines (1934, p. 359). Thus, the known range of the genus is now extended more than 8,000 miles to the Americas. The discovery of *Oxycirrhites* in American waters is of rather great interest from a zoogeographical standpoint. This is especially apparent after a consideration of Ekman's (1935, p. 106) and Myers' (1941, p. 204-205) discussions of the widespread limitations of the ranges of Indo-Pacific species, genera, and even families by the open ocean between Polynesia and America.

Oxycirrhites seftoni, new species

Holotype. S. U. No. 17465, 73.0 millimeters in standard length, dredged at Station 44-D-1, off Palmilla Point which marks the southwest end of San José del Cabo Bay, Baja California, Mexico: 23° 01′ North Latitude, 109° 41′ West Longitude; May 19, 1952. Collectors: J. Böhlke, D. Cohen, J. Lindbergh, F. Cliff, J. Figg-Hoblyn, and J. Savage; 25 fathoms; 18 minute haul; bottom: white sand mixed with some crushed and small whole shells.

Description. Dorsal X,13; anal III,7; pectorals i + 7 + vi (unbranched rays in roman numerals); ventrals I,5-I,5; principal caudal rays 8 + 7.

Body elongate, compressed, its greatest depth occurring below fourth or fifth dorsal spine and contained 4.2 times in standard length. Caudal peduncle moderate, its least depth 1.9 in its length.

Head long, 2.4 in standard length. Snout very long, narrow, 2.1 in head; width of snout at premaxillary groove 9.1 in head; distance from tip of snout to premaxillary groove 4.2 in length of head (when mouth is closed). Premaxillaries extremely produced, giving the mouth a beaklike effect. Maxillaries short, originating far back, at about midpoint of snout. Mouth protractile, the premaxillary process reaching (when mouth is closed) a vertical with the front margin of the eye. Lips wide, with free margins; upper not continuous around tip of snout. Upper lip broadly expanded over top of snout anteriorly (though not meeting on the dorsal midline), becoming nar-

[1] Submitted for publication December, 1952.

rower posteriorly. The point of greatest expansion occurs approximately a pupil's diameter behind tip of snout. Lower lips also broadly lobed across ventral surface of chin at a point slightly behind tip of lower jaw, deeply incised but continuous across tip of chin. Nostrils immediately in front of eyes; anterior nostril tubular with a flared rim, bearing a trifid cirrus on its posterior margin. Lobes of cirrus long, narrow, finger-like; inner lobe longest, reaching nearly to rear margin of posterior nostril when appressed. Distance from tip of snout to anterior nostril 2.5 in length of head. Posterior nostril a horizontally elongate oval opening without raised margins or flaps, placed slightly nearer margin of eye than anterior nostril; distance from tip of snout to posterior nostril 2.2 in head.

Eye moderate, placed high on head, its upper margin entering the dorsal profile; diameter of eye 6.3 in head. Interorbital narrow, concave, its least bony width 1.5 in eye, 9.4 in length of head. Postorbital length of head 2.8 in total length of head. Teeth of upper jaw in villiform bands, the single outer row of approximately 58 on each side somewhat enlarged. Vomerine teeth in a wide villiform band which becomes biserial posteriorly; this series extends back slightly more than halfway from tip of snout to premaxillary groove. Mandibular teeth similar to those of upper jaw, but with the outer series somewhat larger. Teeth of lower jaw included within those of upper jaw when mouth is closed.

Margin of preopercle strongly serrate both behind and below, a total of 22 denticles on the left side, 21 on the right. Suprascapular margin serrate, bearing 5 or 6 denticles. Opercular spine wide, flat and very thin. Opercle ending in a rounded, fleshy lobe which projects backward above and beyond upper end of pectoral base. Gill membranes united, free from isthmus, free end of fold about on a vertical with angle of preopercle (exclusive of the spines). Gill rakers 3 + 1 + 11 on the first gill arch; first raker of lower series the longest, its length approximately 2.5 in interorbital.

Scales cycloid; present on body, fins, preorbital, cheeks, and opercles; absent from top of head, including interorbital region and tip of snout. Scales on cheek in three complete rows, plus a few scales behind which form an incipient fourth series. Scale rows on body parallel both above and below lateral line. Lateral line with 51 scales, 4 above to origin of spinous dorsal, 10 below to origin of anal; 9 predorsal scales. Scales present on interradial membranes of vertical fins as follows: on the anal fin covering nearly the entire membrane between the third spine and first ray, covering the basal one-third of the membrane between first and second rays, and becoming less extensive posteriorly; on the spinous dorsal fin a few scales between the bases of the spines, but no extensive covering of the membranes; on the soft dorsal fin continued out for more than half the length of the last dorsal spine between that spine and the first ray, covering less and less of the membranes posteriorly. Caudal fin scaled for slightly more than one-third the lengths of the lobes with small, regularly-imbricate scales. Bases of pectorals scaly.

Dorsal fins high; dorsal spines increasing in size to the fourth which is longest, thereafter decreasing till the tenth, which is again somewhat longer. Soft dorsal higher than the spinous, its distal margin nearly a straight line. Notch between ninth and tenth spines moderate, the interradial membrane between these spines extending not quite halfway up from the base of the tenth spine. Membranes between dorsal spines deeply incised. Anterior portions of these membranes continued beyond tips of spines as clusters of cirri; three cirri above first spine, three above second, four above third, three above fourth, four above fifth, three above sixth, two above seventh, one each above eighth and ninth, none above tenth. Distances from tip of snout to first dorsal spine 2.4, and to first soft dorsal ray 1.5 in the standard length.

Origin of anal fin below second soft dorsal ray, its distance from tip of snout 1.4 in standard length. Anal spines strong, the second longest, 3.0 in length of head. Anal rays higher than spines, the first ray longest. Caudal fin distinctly emarginate (slightly forked), the shortest branched ray reaching five-sevenths of the way out on the upper caudal lobe. Origin of ventrals below interspace between fourth and fifth dorsal spines, the tip of the longest (first branched) ray reaching to anus, its length 2.7 in head. Last ventral ray connected to abdomen by a membrane. Ventral spine much shorter than first branched ray, its length 4.1 in length of head.

Single uppermost and six lower pectoral rays unbranched. Lower unbranched rays thickened, their tips rounded, and the intervening membranes deeply incised. Branched rays all of nearly the same length, the lowermost only slightly the longest. The first of the lower unbranched rays only slightly longer than the last branched ray, the second unbranched ray abruptly and distinctly longer than the first, and the succeeding rays progressively shorter. Second unbranched ray reaching beyond anus, nearly to first anal spine, when the fin is appressed.

The following are some proportions from the holotype of *O. seftoni*:

Percentages of the following in the standard length:

Length of head	42.5
Greatest depth of body	23.8
Tip of snout to spinous dorsal	41.5
Tip of snout to first soft dorsal ray	67.8
Tip of snout to upper pectoral base	40.5
Tip of snout to base of ventrals	50.0
Tip of snout to origin of anal	69.9
Least depth of caudal peduncle	9.7
Lengths of:	
caudal penduncle	18.5
shortest branched caudal ray	16.2
upper caudal lobe	23.0
lower caudal lobe	22.2
first dorsal spine	5.9
second dorsal spine	12.1
third dorsal spine	16.4
fourth dorsal spine	17.9
fifth dorsal spine	17.7
sixth dorsal spine	16.6
seventh dorsal spine	14.4
eighth dorsal spine	12.5
ninth dorsal spine	9.9
tenth dorsal spine	11.8
first dorsal ray	19.3
first anal spine	5.9
second anal spine	14.1
third anal spine	11.8
longest anal soft ray	16.8
ventral spine	10.3
longest branched ventral ray	15.5
longest branched pectoral ray	18.5-19.2 [2]
first unbranched pectoral ray	20.5-21.4
second unbranched pectoral ray	25.3-25.8
third unbranched pectoral ray	22.7-22.6

Percentages of the following in the head length:

Diameter of eye	15.8
Length of snout	48.1
Least width of bony interorbital	10.6
Tip of snout to end of maxillary	36.1
Postorbital part of head	36.1
Tip of snout to anterior nostril	40.6
Tip of snout to posterior nostril	45.5
Tip of snout to premaxillary groove	23.5
Width of snout at premaxillary groove	11.0

Color in Alcohol. The basic color pattern consists of dark longitudinal and vertical bars that form a cross-hatched effect over a light background. The parts which are dark on the preserved specimen were red in life, the ground color whitish. There are apparently nine obliquely vertical bands (3 or 4 scales wide) on the body, and continued somewhat onto the dorsal fin. Upper end of first band at base of first dorsal spine, second at base of sixth spine, third (indistinct) at base of eighth spine, fourth at base of tenth spine, fifth at base of fifth ray, sixth at base of tenth ray, seventh just behind base of last ray, eighth at middle of caudal peduncle, and ninth at bases of caudal rays. Several indistinct vertical bands on caudal fin and its rays tipped with black. Three longitudinal lines present on body: one above, one at, and one below the lateral line; equally spaced. Two well-defined longitudinal bars on spinous dorsal; these are continued, less distinctly, onto the soft dorsal. Anal fin dusky but with no well-defined markings.

[2] The two figures given for this and the three following fin ray measurements refer to both the left and right sides of the fish—in that order.

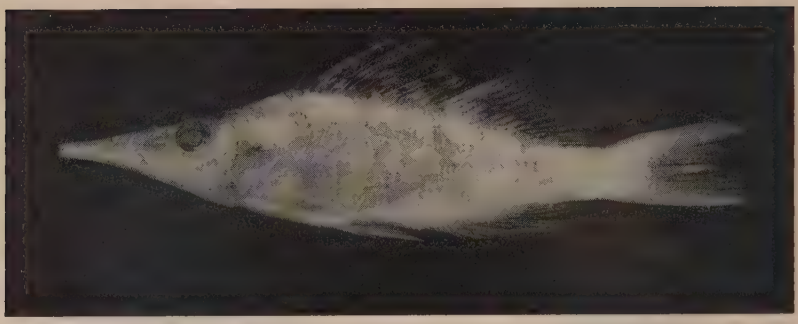

FIGURE 1. Holotype of *Oxycirrhites seftoni*. S. U. No. 17465, 73 mm. in standard length.

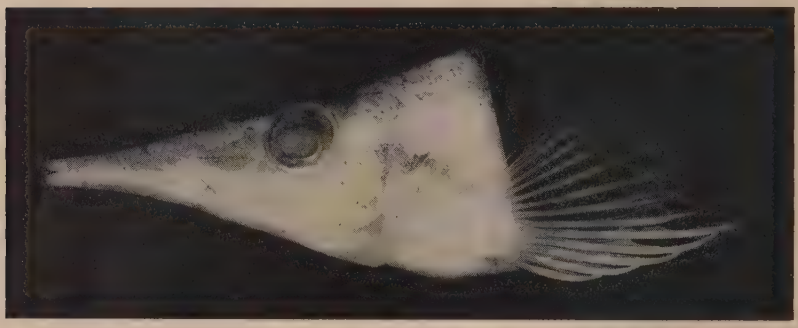

FIGURE 2. Head and pectoral fin of the holotype of *Oxycirrhites seftoni*, to show the outline of the pectoral fin with the abruptly longer second unbranched ray.

FIGURE 3. Bleeker's (1876-1877) figure of *Oxycirrhites typus*. Note the differences in color pattern between this figure and Figure 1.

Relationships

With only four specimens of the genus now known, it is quite impossible to determine whether Fowler's *Oxycirrhites morrisi* would fall within the range of variation of *O. typus* Bleeker. For this reason, the nominal forms are considered as distinct in this paper, even though Smith (1951, p. 633) synonymized the two. From *O. typus,* the new species differs as follows (utilizing for comparison the figures in Bleeker 1876-1877, Pl. 351, Fig. 2, and in de Beaufort 1940, p. 15, Fig. 4; and the description as given in the latter): in the very different placement and size of the bars on the body (see Figures 1 and 3), the much longer second lower unbranched pectoral ray (equal to snout in *typus,* much longer than snout in the new species), the relative sizes of the third and tenth dorsal spines (equal in *typus,* the tenth much shorter in the new species), the relatively shorter second anal spine (equal to postorbital part of head and half eye in *typus,* shorter than postorbital part of head in the new species), the shorter ventral spine, slightly larger eye, and more numerous preopercular serrations.

From *Oxycirrhites morrisi,* the new species differs as follows: in having more scales in the lateral line (45 in *morrisi,* 51 in the new species); a shorter third dorsal spine (2.25 in head for *morrisi,* 2.6 in head for *seftoni*); a shorter second anal spine (2.5 in head for *morrisi,* 3.0 in head on the new species); different pectoral ray combination (iii,6,v in *morrisi,* i,7,vi in the new form); a slightly shorter snout, smaller eye, and more numerous denticles on preopercle; and particularly in the longer pectoral fin with the second lower unbranched ray abruptly and distinctly longest, the fin length 2.5 in head for *morrisi,* 1.6-1.7 in head for the new species. This difference in shape of pectoral fin is readily apparent from the following fin-ray measurements (in millimeters) made on the two holotypes.

	O. morrisi		*O. seftoni*	
	left	right	left	right
Longest branched ray	13.1	12.1	13.5	14.0
First unbranched ray	12.2	13.8	15.0	15.6
Second unbranched ray	11.5	14.9	18.5	18.8

Dr. Schultz writes that the pectoral fins of the holotype of *morrisi* are undamaged.

The new species is named *seftoni* for Mr. Joseph W. Sefton of San Diego, California, who generously sponsored the expedition that captured this very interesting fish, and whose genuine interest in fishes has aided and stimulated many investigators in the past aboard the *Orca.*

Acknowledgments

The writers wish to acknowledge the criticisms and suggestions offered by Dr. George S. Myers of Stanford, Dr. Carl L. Hubbs of the Scripps Institution of Oceanography and Dr. Boyd W. Walker of the University of California at Los Angeles; and the assistance given by Dr. Leonard P. Schultz of the U. S. National Museum who kindly made pectoral fin ray measurements on the holotype of *Oxycirrhites morrisi* Fowler. Their thanks are also extended most sincerely to Sr. Antenor Leitão de Carvalho, Naturalista, Museu Nacional, Rio de Janeiro, Brazil, for preparing the photographs that illustrate this paper.

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SPOTTED CUSK-EEL, THE STRANGE FISH THAT STANDS ON ITS TAIL[1]

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At various times Steinhart Aquarium has exhibited spotted cusk-eels (*Otophidium taylori*). Because not much is known about the biology of this intriguing fish, the observations and experiences reported herein may prove of interest.

Cusk-eels belong to Family Ophidiidae and are closely related to our common tidepool blennies. There are about 30 known species, only three of which are found in California. Although most cusk-eels are less than 12 inches when full-grown, there are others which grow to a much larger size. In South Africa the famed deep water kingklip (30-250 fathoms) reaches a length of five feet and is considered a great delicacy. In Peru there is a commercial fishery for two smaller species of cusk-eels (maximum length two and one-half feet) that live in 20 to 50 fathoms of water.

Most cusk-eels seem to prefer deep water. Occasionally the California species have been taken in the shallow water of tide pools and estuaries. Years ago the writer collected his first specimen among eel-grass in four feet of water in Point Mugu Lagoon near Oxnard, California. Sometimes specimens are found among the sardine catches in canneries at San Pedro. During the war the U. S. Navy conducted a series of deep-water blasting experiments off Southern California and cusk-eels were found floating at the surface after the explosions (verbal communication from Dr. R. R. Harry). Three specimens have been taken in San Francisco Bay, two from the Pacific Gas and Electric Plant at Third and Twenty-third Streets, and one from the Chinese shrimp nets. Our recent specimens have come from the octopus traps which are fished at depths of 100 to 600 feet in Monterey Bay. It is surprising that a fish such as the cusk-eel could make this rapid ascent from deep water without showing ill effects, since all cusk-eels possess air bladders. Dr. Harry finds from dissection that the posterior end of the air bladder is usually very thin. This would allow quick diffusion of gases so that an individual would be able to make a rapid ascent to the surface without injury.

When placed in an aquarium, *Otophidium taylori* seems to adapt itself quickly to its new surroundings and soon demonstrates its "at ease" posture—standing vertically, and supported by its tail pressed against the bottom (Figure 1). Although cusk-eels have been known for years, a search of the literature revealed no instance where they have been reported as being tail standers.

External disturbances seem to have little influence upon this phlegmatic fish. A stick pushed against the side of the body only causes

[1] Submitted for publication January, 1953.

FIGURE 1. Resting with the pectoral fins extended as balancers, the spotted cusk-eel is at peace with the world. *Photograph by Frank Rogers.*

taylori to flutter the pectoral fins quickly as though attempting to maintain its balance in the vertical position. On one occasion a giant nudibranch slug oozed over the entire trunk and tail of *taylori* but again the fish never moved. When tail-standing, slight disturbances often cause

FIGURE 2. Spotted cusk-eel in "ALERT" position, starting to extend the thread-like throat fins. *Photograph by Frank Rogers.*

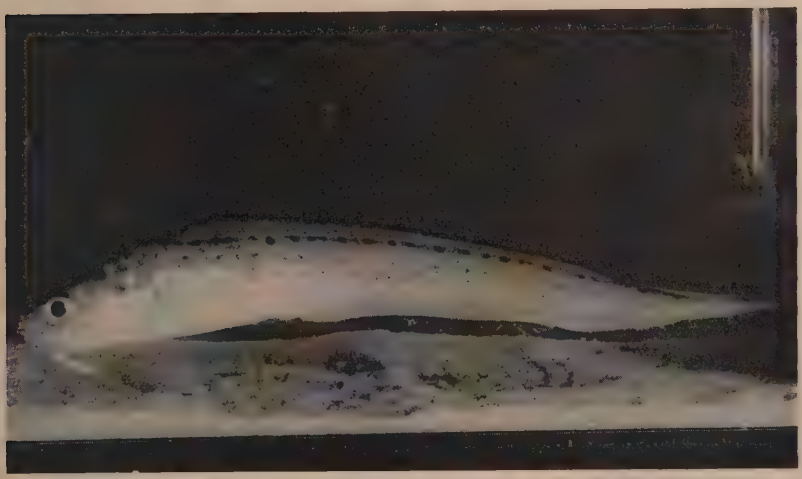

FIGURE 3. When searching for food, the spotted cusk-eel extends throat fins like a mine detector, dragging them along the bottom. *Photograph by Frank Rogers.*

taylori to erect its ventral fins which are no more than small thread-like filaments attached to the throat (Figure 2). These throat fins apparently have some tactile function and are important in finding food. At times *taylori* will swim at about one-half inch above the bottom with the throat fins extended downward, dragging them through the sand as though they were the tines of a rake (Figure 3).

In addition to being a tail stander, *O. taylori* is also an active tail borer. It customarily enters cavities and crevices tail first, allowing only a portion of the head to protrude from the hole. When placed in a small tank containing one or more glass tubes, *taylori* will invariably do its tail standing with the tail inserted in one of the tubes. This affinity for backing into unknown apertures has its serious side, for one day *taylori* appropriated an unused submerged drain pipe for its home. The first day its head was visible, projecting from the pipe. The second day it had moved two inches farther into the pipe so that we could see it only with a flashlight. On the third day it disappeared. The writer carefully inserted a long pencil into the pipe and could barely touch the cusk-eel some seven inches down the pipe. Then there began a series of frantic schemes to try to remove it from the pipe without injury. Finally two days later, biologist Bob Dempster hit upon the proper method. Using long forceps, he shoved a wriggling salmon fingerling into the pipe just in front of *taylori*. The cusk-eel tried to eat the fingerling and while so occupied, the salmon was pulled out with the eel hungrily attached. Needless to say, this drain was then thoroughly blocked.

The feeding of cusk-eels can sometimes be a problem as shown by an individual which biologist Donald Simpson collected at San Francisco's P. G. and E. plant (January, 1945). This fish lived for nine months in a 16-gallon tank where it spent most of the time buried in the sand with only the head protruding. It refused food for the first 20 days although offered such tempting tidbits as cut fish and meat, small crabs, earthworms, brine shrimp and marine algae. Finally some mosquito fish were tried, and they turned the trick. Thereafter this cusk-eel consumed one to four mosquito fish per day. The manner in which the food was taken was most interesting. The mosquito fish would swim about in the tank, and the cusk-eel would seem to be totally oblivious of their presence until suddenly one of them would come in close proximity to the throat fins. Then quickly the cusk-eel would come to life, and moving faster than at any other time, would devour the hapless mosquito fish at one gulp.

The staff of the aquarium still has much to learn about cusk-eels, but what has been observed to date indicates that they are a most interesting subject.

A NESTING STUDY OF CANADA GEESE ON TULE LAKE AND LOWER KLAMATH NATIONAL WILDLIFE REFUGES, SISKIYOU COUNTY, CALIFORNIA[1]

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INTRODUCTION

The nesting of Canada geese (*Branta canadensis moffitti*) in California is limited to the northeastern section of the State, including Siskiyou, Modoc, Lassen, Shasta, and Plumas Counties. That area produced an estimated 17,850 geese in 1951 (Crissey, et al., 1951). Nearly one-half of the geese produced during that year were reared on the Tule Lake and Lower Klamath National Wildlife Refuges in Siskiyou County. Because of their importance as goose nesting areas, these refuges were chosen as sites for an extensive goose nesting survey conducted in the spring of 1952. The purpose of the survey was to furnish additional basic data pertaining to goose production and the fundamental needs and preferences of nesting geese.

During this survey 201 nests were located. It was found that muskrat houses and islands were the preferred nest sites. Factors in selection of nest sites seemed to be visibility, protection afforded, proximity of other nesting geese, and distance to water. A total of 158 nests, or 78.6 percent, hatched successfully. The major causes of nest failures were desertion and flooding. Nest destruction by predation was of little consequence.

Tule Lake and Lower Klamath Lake once represented a total of more than 120,000 acres of shallow lake and natural marsh before reclamation projects began in about 1900. Tule Lake, originally some 40,000 acres, diminished in size owing to the advent of agriculture in the area to about 11,000 acres which was established as a refuge in 1928. The acreage of the refuge was subsequently increased to 37,340 acres in 1936, but in the intervening years has decreased to approximately 32,000 acres due to homesteading of agricultural lands. Lower Klamath National Wildlife Refuge, containing 81,619 acres, was established in 1908. This was among the first of the important waterfowl reservations in the western states to be placed under the supervision of the Biological Survey, now the Fish and Wildlife Service. Lower Klamath Lake was later drained and futile efforts made to farm the lake bed with the result that in 1942, 21,000 acres of the old lake bed were re-established as refuge (Jewett, 1943).

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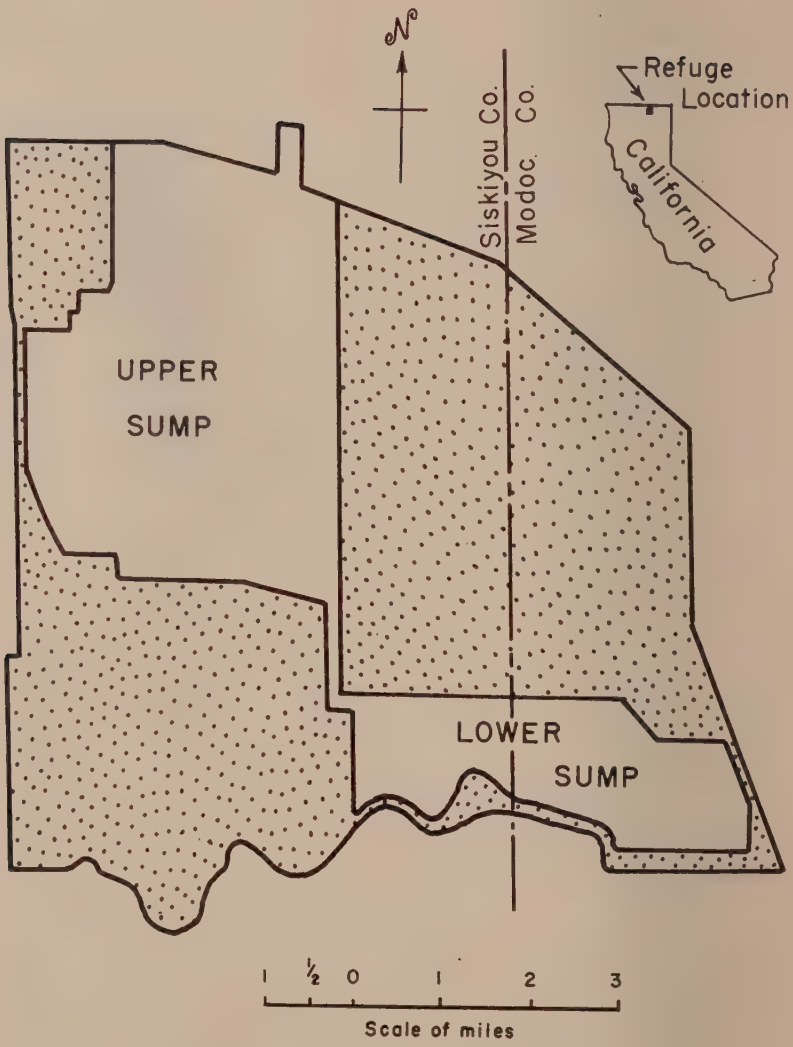


FIGURE 1. Tule Lake National Wildlife Refuge

During 1952, Tule Lake Refuge comprised approximately 13,000 acres of water area maintained in two restricted sumps (Lower Sump and Upper Sump, Figure 1). The balance of the refuge was in agricultural lands devoted mainly to barley and potato culture. The water depths of the sumps averaged two to three feet and about one-third of the Upper Sump supported a dense stand of hardstem bulrush (*Scirpus acutus*) and cattail (*Typha latifolia*). Lower Klamath Refuge was still in the process of being developed as an improved waterfowl habitat. The refuge consisted of four developed units (2, 3, 4 and 9)

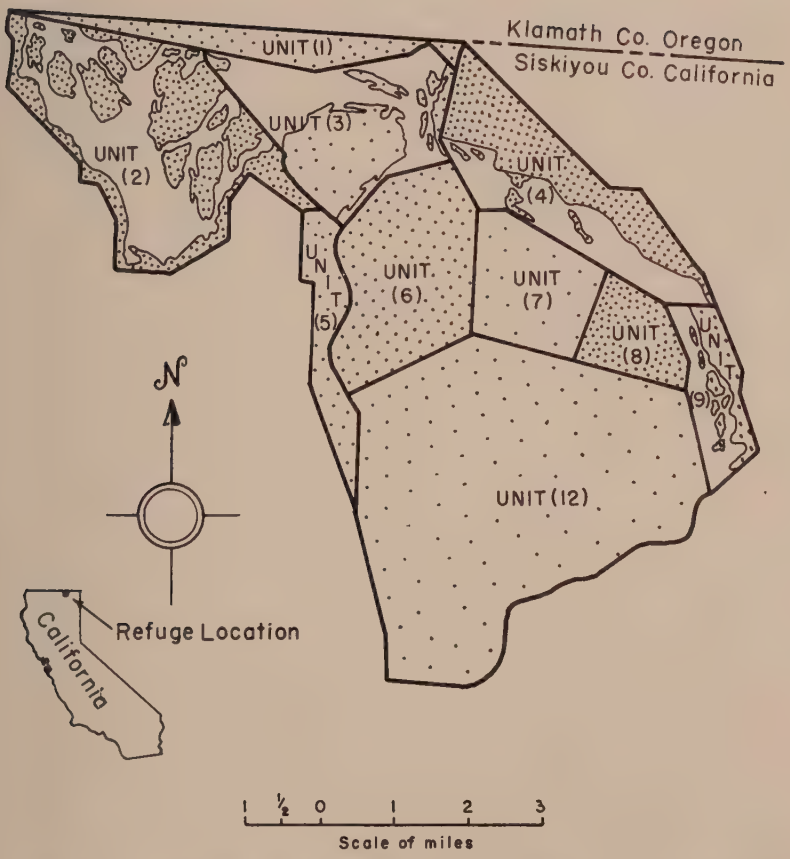


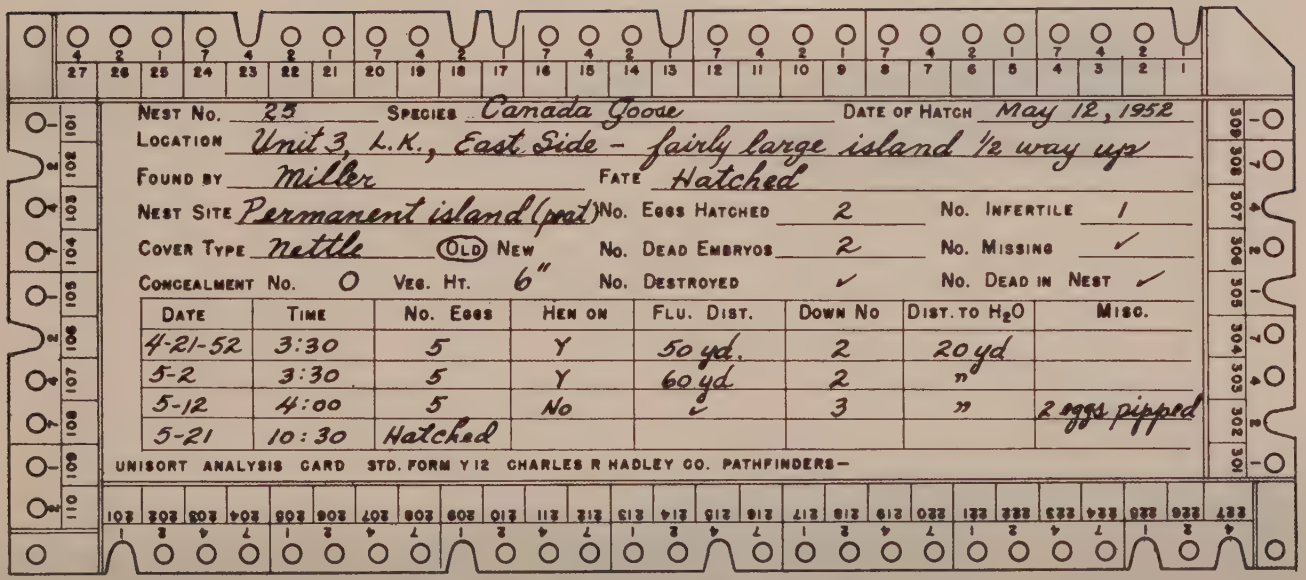
FIGURE 2. Lower Klamath National Wildlife Refuge. (This map does not show differentiation between open water and areas of emergent vegetation.)

with impoundments of open water interspersed with patches of emergent vegetation, islands, and other areas of dry land (Figure 2). Five additional units (5, 6, 7, 8 and 12) were in the process of development. Unit one was under cultivation as were parts of units 3, 4, 6 and 9.

PROCEDURE

Each major unit of the refuges that supported nesting geese in significant numbers was included in the survey but not all of the area of each unit was necessarily searched. In general, the survey crew covered only as much territory in any one unit as could be rechecked in one day. Thus, no birds were disturbed two days in a row. Enough nests were located over the whole area to be representative of the nesting conditions existing at the time of the survey.

Wherever practical, the search for nests was made with an airboat loaned by the refuge management. The speed and versatility of the boat



NEST NO. 23 SPECIES Canada Goose DATE OF HATCH May 12, 1952

LOCATION Unit 3, L.K., East Side - fairly large island ½ way up

FOUND BY Miller FATE Hatched

NEST SITE Permanent island (peat) No. EGGS HATCHED 2 No. INFERTILE 1

COVER TYPE Nettle (OLD) NEW No. DEAD EMBRYOS 2 No. MISSING ✓

CONCEALMENT No. 0 VEG. HT. 6" No. DESTROYED ✓ No. DEAD IN NEST ✓

DATE	TIME	NO. EGGS	HEN ON	FLU. DIST.	DOWN NO	DIST. TO H_2O	MISC.
4-21-52	3:30	5	Y	50 yd.	2	20 yd	
5-2	3:30	5	Y	60 yd	2	"	
5-12	4:00	5	No	✓	3	"	2 eggs pipped
5-21	10:30	Hatched					

UNISORT ANALYSIS CARD STD. FORM Y 12 CHARLES R HADLEY CO. PATHFINDERS—

FIGURE 3. Nest card. Hadley Unisort Y-12 card adapted for nest data showing information entered and punched for sorting with a stylus.

made it possible to cover more marsh habitat in less time than by any other means. Where emergent vegetation was too rank, or when nesting occurred on large areas of dry land, the searching for nests was done on foot. The large size of Canada geese, the presence, usually, of the male guarding the territory and the proclivity of the nesting pairs to select nest sites which afforded good visibility of surrounding terrain were characteristics favorable to the location of nests. A man standing up in a boat or on the top of a muskrat house could with the aid of binoculars often spot the location of any nest in the immediate area.

Each nest found was assigned a number and the data recorded on a prepared nest card bearing the same number (Figure 3). To aid in relocation and identification, each nest was marked with a willow stake or wood slat also bearing the nest number. The stakes were placed about 10 feet from the nest and in line with a chosen landmark common to all nests of the area (Naylor, 1953). Revisits were made and data recorded at intervals of 10 days.

DATA COLLECTED

The study began on April 3, 1952, and was concluded May 23, 1952, upon completion of the last nest history. A total of 203 goose nests was located and recorded, 88 on Tule Lake Refuge and 115 on Lower Klamath Refuge. One nest with an unknown number of eggs was hatched when found and the location of another was lost, leaving 201 complete nest histories for this summary. Estimates made by the Fish and Wildlife personnel indicated a total of 530 nesting pairs of geese on the two refuges (Chattin, et al., 1952). Using that figure as a basis, it was concluded that the sample taken for this survey represented approximately 38 percent of the nests occurring on the areas.

Nest Sites and Cover Types

The nest sites listed in Table 1, for the most part, are self-explanatory. It may be well, however, to define some of the less definite classifications. Bulrush mats were heavy, lodged growths of dead hardstem bulrush from the previous year or the feeding platforms of muskrats made of the same material. Uncultivated or waste land occurred above the normal water level and supported a rank growth of grasses and weeds. Dikes, levees and ditch banks were all elevated margins of bodies of water.

Muskrat houses were found in greater numbers on the Upper Sump of Tule Lake than on any other of the samples. This area accounted for 68 percent of the muskrat house sites utilized. Twenty-eight percent

TABLE 1
Location of Nest Sites

Site	Number of nests	Percent
Muskrat house	78	38.8
Island	76	37.8
Bulrush mats	21	10.4
Uncultivated or waste land	14	7.0
Dikes, levees or ditchbanks	12	6.0
Totals	201	100.0

were on Lower Klamath, leaving only 4 percent for the Lower Sump. The lack of extensive stands of emergent vegetation to support a muskrat population on the Lower Sump, Tule Lake, was responsible for the lack of muskrat house nest sites there. Of the nests found on island sites, 34 percent were on small islands in the Lower Sump with the balance on Lower Klamath. The islands found on the Lower Sump were artificially created while those on Lower Klamath were natural, formed by the interspersion of land and water areas due to the surface irregularities of the land. The islands on Lower Klamath range from small peat hummocks to extensive tracts comprising several hundred acres (Figure 2).

Bulrush mats used as nest sites by geese served essentially the same purpose for nest construction as did the muskrat houses but the frequency of usage was less. Of the nests found on bulrush mats, 71 percent were located on Lower Klamath. Over 70 percent of the nests found on uncultivated areas were found placed on peat hummocks and similarly raised places. Dikes, levees and ditch banks that were not traveled by vehicles were utilized as nest sites by some geese.

The selection of nest sites by geese in this area seemed to have been based on a number of interacting factors: (1) Visibility of surrounding terrain, (2) protection afforded, (3) proximity of other nesting geese and (4) the distance to water (61 percent of the nests were within three yards of open water and only one nest was found more than 50 yards from water). Concealment of the nest site seemed to be of little importance. Similar conclusions regarding nest sites of Canada geese were reached by Dow (1943), Naylor (1953), Williams and Marshall (1937), and Kossack (1950). However, Craighead and Craighead (1949) mentioned a tendency toward the concealment of nests by geese along the Snake River.

In Table 2 the listing of specific plants to illustrate cover types was regarded as the simplest procedure, rather than describing physical characteristics of each type. Only the dominant species of the plant community at each nest site was recorded. At the time the geese were selecting nest sites (March and April) only dead vegetation from the previous year was present. Some new growth had begun during the later part of the goose nesting period but was not high enough to be of importance as cover.

TABLE 2

Cover Types Utilized

Cover type	Number of nests	Percent
Hardstem bulrush	95	47.2
Nettle	48	23.9
Saltbush	35	17.4
Cattail	6	3.0
Grasses	4	2.0
Mustard	1	0.5
Others*	12	6.0
Totals	201	100.0

* Included reed grass, various grasses and composites, and barren sites.

The importance of hardstem bulrush was due mainly to its use by muskrats for construction of houses upon which nests were built. The apparent high utilization of nettle (*Urtica californica*) and saltbush (*Atriplex* sp.) resulted from the use of island nesting sites. Some islands used were mounds of peat supporting dense growths of nettle while others of heavier soils supported patches of saltbush. Cattails, as well as reed grass (*Phragmites* sp.), were used to a limited extent by muskrats for house construction accounting for their utilization by geese as nest cover. Two nests were recorded on muskrat houses constructed of reed grass. Six nests were found on sites devoid of vegetation (five on islands).

The service rendered by plant cover to goose nests found on muskrat houses and bulrush mats was to provide a base upon which to build the nest, with the site rather than the cover being of primary importance. In all other instances, nest cover for concealment of the nest was also of secondary importance, and seemed incidental to the choosing of the nest site. At least one island and parts of others where goose nesting occurred were completely devoid of cover and the nests were simply depressions in the ground with a few weed fragments and down for lining. All other nests were built on the ground with surrounding vegetation providing nest material.

Fate of Nests

Five categories, with definite limitations governing the recording of each, were outlined for classifying fates of nests.

1. Hatched nests were recorded, whether some or all eggs had hatched, when the completed nest contained shell fragments and membranes resulting from hatched eggs.
2. Nests were considered deserted if egg laying or incubation had ceased with no evidence of destruction or flooding having taken place.
3. Nests were regarded as flooded when the surrounding water level raised above the level of the nest or when the nest site was close enough to the water level that wave action caused by high winds was sufficient to wash over the nest. Wave action either destroyed the nest site entirely or made the nest untenable, causing subsequent abandonment. This category seemed desirable to eliminate the necessity of distinguishing between nest desertion and nest destruction due to the effect of rising water level or wave action.
4. Destroyed nests were defined as those showing some evidence of having been molested; i.e., shell fragments from destroyed eggs in and about the nest, presence of destroyed eggs, down scattered, eggs missing with no evidence of hatching present, etc.
5. A nest was classified as fate unknown when all eggs or remains of eggs were missing with all traces of the nest obliterated and no clues to the fate ascertainable.

The nesting success in this study was 78.6 percent with 158 of the goose nests hatched from the 201 nest sample. Dow (1943) reported a nesting success of 52.2 percent in 1939 and 60 percent in 1940 at Honey Lake Refuge, Lassen County, California. Naylor (1953) recorded a nesting success of 68.3 percent in 1951 for the same area.

TABLE 3
Fate of Nests

Fate	Number of nests	Percent
Hatched	158	78.6
Deserted	23	11.4
Flooded	10	5.0
Destroyed	5	2.5
Unknown	5	2.5
Totals	201	100.0

Desertion, the greatest factor causing nest failure in this study, was attributed mainly to intraspecific strife on heavily populated islands where competition for nest sites was acute. The activity of muskrats in and about their houses was also believed to be a factor. The desertion of nests on crowded islands amounted to 13 nests or 56.6 percent of the total nests deserted. Deserted nests built on muskrat houses amounted to 26.1 percent, leaving 17.3 percent desertion for all other sites. Naylor (1953) found desertion of nests by Canada geese at Honey Lake Refuge involved 23.9 percent of the total sample of nests taken. This desertion was mainly attributed to crowded conditions on islands. From a sample of 88 goose nests along the Snake River, Craighead and Craighead (1949) made particular note that no intraspecific strife was apparent during the breeding season in the area studied. Although they did mention the possibility of desertion having taken place, no nests were definitely recorded as such.

Human interference by those making the study, as a cause of desertion was considered unimportant since visits were made at relatively long intervals, three or four at most during an entire nest history. During a visit, only as much time as was necessary to record data, two to three minutes, was spent at each nest. The tolerance to human activities in some cases is considerable. For instance, one nest was located within 20 yards of a road traveled every working day by a fleet of 8 to 10 gravel trucks making several trips each during the day. Upon questioning drivers it was learned that the goose left the nest at least once every day due to the activity of the trucks. The nest, though subsequently abandoned, was incubated for about 20 days under those conditions.

The tolerance of nesting geese to human activity has been noted by other writers. Dow (1943, p. 9) wrote, "On March 18, 1940, a goose nest containing two eggs was found on the top of one end of a large haystack, more than 18 feet from the ground. Two or more wagon loads of hay were being taken from the opposite end of the stack each day. As the haystack decreased in size and the nest was endangered, the rancher considerately moved the nest and eggs to a safer position on the stack. By April 25th, the stack had dwindled to only a small pile and the nest was less than six feet from the ground. The farmer was obliged to move the nest to save the eggs from destruction each time he took hay from the stack. A last visit to the nest revealed that the goose hatched two goslings in spite of the fact that she had been disturbed each day during the incubation period." Kossack (1950) also commented on the tolerance of nesting geese

to human interference in connection with his experiments on incubating temperatures. He found that in no case did a goose desert as a result of his placing atypical (wooden) eggs in the nest or of the cementing of thermocouple wires to eggs in the nest.

Wave action on Tule Lake was responsible for the flooding of goose nests in every recorded case. Nine of the flooded nests were built on muskrat houses from 9 to 15 inches above water level in the Upper Sump and the tenth was built on a small island 12 inches above water level in the Lower Sump. Old, partially decayed muskrat houses were particularly susceptible since they would disintegrate quite easily, leaving eggs floating in the resulting debris.

All destroyed nests and those of unknown fates were located on muskrat houses. There was no case of nest destruction that could be attributed to any specific nest predator although the coyote, skunk, weasle, mink, ground squirrel, ring-billed and California gulls, magpie and raven are known to occur in the area. Destruction of goose nests by predation seemed to have been of little significance in this study because of its low level (2.5 percent). Some nests classified as fate unknown could have been destroyed, deserted or hatched but no corroborating evidence could be found.

Fate of Eggs

To determine fate of eggs and average clutch, only the data from successful nests were used to avoid possible distortion of figures. To include egg data from all nests would require hypothetical criteria to be set up to determine for flooded or deserted nests the probable number of eggs that should have hatched, resulted in dead embryos, or have been infertile. Where some eggs were destroyed or missing, there was no way for an examination to be made to determine probable outcome.

The successful nests produced 810 eggs of which 705 hatched, giving a hatching success of 87 percent. The average clutch in successful nests was 5.13, and the average hatch per nest, 4.43. These figures compare favorably with average clutch and hatching success found in comparable studies.

The 91 unhatched eggs were grouped into two classifications according to Kossacks' method of determination between infertile eggs and those containing dead embryos (Kossack, 1950). Unhatched eggs were regarded as infertile when the yolks were found to be wholly or partially suspended in the albumen. All others were classified as dead embryos in various stages of development. Fifteen or 1.9 percent of the 810 egg sample was found to be infertile and 76, 9.4 percent, contained dead embryos. Naylor (1953) found 2.0 percent of the eggs to be infertile from a sample of 350 eggs; 29 percent contained dead embryos. Kossack reported 4.6 percent infertility from 325 eggs in 1945 and 1.7 percent from 404 eggs in 1946.

The 14 eggs unaccounted for were either destroyed or missing prior to the termination of the nest histories. These eggs were not considered as a source of error in determination of any factor in the fates of eggs. They should be regarded as an index to the number of eggs from otherwise successful nests that would meet unknown fates during the course of a nesting season in this area. It is quite likely, however, they would have hatched, contained dead embryos, or have been infertile in the same ratio as given above.

Five newly hatched young were found dead in their nests but only speculation concerning probable cause can be given. It is possible that accidental crushing by the parent, chilling while still wet, or delayed hatching (or a combination of the latter two) could cause death of young birds. It is also possible that weak individuals, barely able to emerge from the egg, would succumb almost immediately after hatching. The low incidence of this factor, however, makes it of little significance (5 out of 705 that hatched).

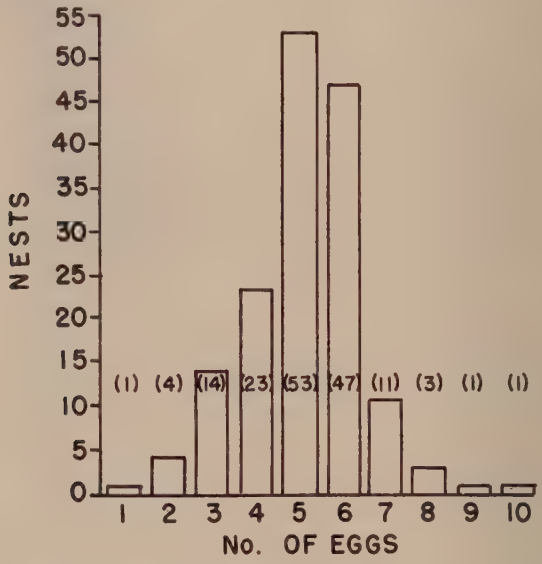


FIGURE 4. Clutch size frequencies of Canada geese on Tule Lake and Lower Klamath Refuges, 1952.

Figure 4 shows clutch size frequencies in successful nests to illustrate more clearly the application of an average clutch figure to a nesting population of geese. Although the extremes of clutch size vary from one egg to 10, the frequencies of occurrence are overwhelmingly greater in the size range of clutches from four to six eggs (77.9 percent). The extreme clutches of one to three eggs and from seven to ten eggs average 4.83 eggs per clutch closely approximating the figure given for over-all average clutch (5.13).

An adequate sample of extreme clutch sizes, large or small, was not obtained to attempt any determination of the relative success of small or large clutches as compared to the average sized clutches of from four to six eggs.

Nesting Period and Date of Hatch

The first nest was located on April 5th and was later discovered to have contained a full clutch of eggs at the time it was found. That nest hatched in the period between April 16th and April 28th. The first brood of geese was reported by an employee of the Fish and Wildlife Service on April 16th. The above information would place the beginning of the nest-

ing season about March 15th. Nesting continued until about June 6th when the last week-old brood was estimated as having hatched, although the last nest history in the sample was completed May 23d. From the above data it was concluded that the 1952 goose nesting season in the Klamath Basin was approximately 83 days. This is a longer period for goose nesting than reported by Naylor (1953) and Dow (1943) at Honey Lake, California, or by Kossack (1950) in Illinois, or Marshall and Williams (1937) at Bear River in Utah.

The peak of the hatch fell during the period from April 23d to May 12th with 87 percent of the hatch taking place during that 20-day period (Figure 5).

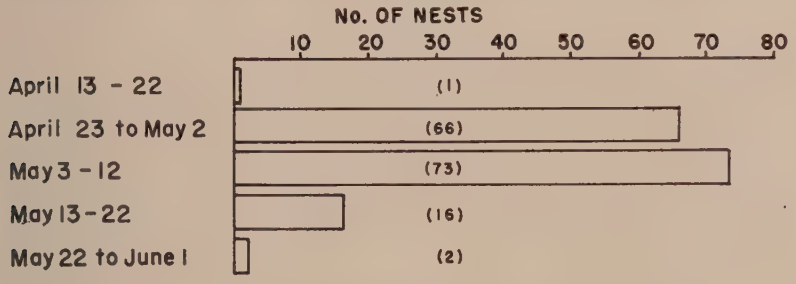


FIGURE 5. Peak of hatch of Canada goose nests found on Tule Lake and Lower Klamath Refuges, 1952.

Brood Data

Brood data from a sample of 76 Canada goose broods one week old, taken during the nesting study, is presented in Table 4 for comparison with the average number of young produced from the successful nests in the study. The average brood from the counts taken was 5.14 or .71 birds more than the average number hatched from successful nests (4.43), indicating that sufficient grouping of broods occurred during the first week of life to mask any regression that might have taken place. Further grouping among older broods masked regression even more. Thus, no information concerning mortality of young geese could be obtained. The inclusion of data concerning the size of older broods was therefore considered unimportant.

TABLE 4
Brood Counts of Week-old Broods

Brood size	Number of broods	Number of young
1	1	1
2	5	10
3	8	24
4	15	60
5	16	80
6	15	90
7	8	56
8	4	32
9	2	18
10	2	20
Totals	76	391

Average Brood Size—5.14

SUMMARY

1. A nesting study of Canada geese was carried out during the spring of 1952 on Tule Lake and Lower Klamath National Wildlife Refuges.
2. A sample of 201 complete nest histories was obtained for this study.
3. Preferred nesting sites chosen by geese were muskrat houses, 38.8 percent, and islands, 36.3 percent.
4. Factors in selection of nest sites seemed to be visibility, protection afforded, proximity of other nesting geese and distance to water.
5. Cover type at the nest seemed to be incidental to the choosing of the nest site.
6. Of the 201 complete nest histories, 158 were successful, giving a nesting success of 78.6 percent.
7. The major causes of the 43 nest failures were desertion, 11.4 percent, and flooding, 5 percent. Nest destruction by predation was of little consequence.
8. Eight hundred ten eggs in successful nests produced 705 young, resulting in a hatching success of 87 percent. The average clutch was 5.13 and average hatch per clutch, 4.43.
9. Of eggs in successful nests, 1.9 percent were infertile and 9.4 percent contained dead embryos.
10. The length of the 1952 nesting period was about 83 days. The peak of the hatch occurred between April 23 and May 12, with 87 percent hatched during that period.
11. No information regarding mortality of young geese could be obtained due to the grouping of broods.

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A NESTING STUDY OF THE BAND-TAILED PIGEON (*COLUMBA F. FASCIATA*) IN NORTHWESTERN CALIFORNIA[1]

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INTRODUCTION

Several preliminary surveys of the band-tailed pigeon population during the summer of 1950 indicated that northwestern California might be utilized as a nesting area by many widely scattered, but apparently decreasing, flocks of pigeons. A study of their nesting cover requirements along with an analysis of the effects of logging operations upon the nesting ecology of the band-tailed pigeon was considered timely. As a result, four objectives were set forth at the start of the study which was undertaken in 1951:

(1) To determine the importance of the northwestern coastal region of California as a nesting area for band-tailed pigeons.

(2) To ascertain the habitat types utilized by the nesting band-tailed pigeons.

(3) To study the factors affecting the nesting and production of band-tailed pigeons in this area.

(4) To make management recommendations to benefit the band-tailed pigeon in northwestern coastal California.

Although it was difficult to actually locate individual band-tailed pigeon nests, utilization of the habitat for nesting was determined from territorial pairs. It was also found that logging, fire, water, and human interference affected nesting. These factors should be given prime consideration in a management program.

MIGRATION

The first band-tailed pigeons arrived in Humboldt County during the last week of March in 1951. The height of the migratory flight occurred during the last half of April but continued strong through June (Table 1). Comparison of the migration with phenological data indicated that Western dogwood (*Cornus nuttallii*) and madrone (*Arbutus menziesii*) were in full bloom at the peak of the spring flight. It was estimated that the total number of band-tailed pigeons observed (1,522) during the spring migration represented about 40 percent of the total migrants

[1] Submitted for publication October, 1952. The writer is deeply indebted to the Wildlife Management Institute for financial assistance on this study and to Mr. Robert Talmadge for permitting the use of certain nesting data.

TABLE 1

The 1951 Spring Migration Data Obtained From 55 Field Observations in Humboldt County

Number observations	Month	Number birds observed
1	March	9
18	April	654
18	May	413
18	June	446

passing through the study area. The rate of migration appeared to have slowed down slightly during May due to inclement weather. Four days was the longest period any single flock of band-tailed pigeons was known to have remained in one area. In most instances, the migrants continued their northward journey with little more than a single day spent in any one vicinity. The migrating flocks varied in size from 3 to 200 individuals but the most commonly observed flocks were composed of 15 to 30 birds.

Sitka spruce (*Picea sitchensis*) groves from 20 to 60 years old were utilized predominantly by the migrating pigeons with redwood (*Sequoia sempervirens*) snags and alder (*Alnus* sp.) of various ages also being used.

FOOD

Several cases of crop depredations in the study area were reported to the local game wardens during the period of migration. An examination of 17 droppings collected May 3 from a communal roosting grove indicated that oats had been the major food item. Eleven crops (four in May, 1948, and seven in June, 1951), obtained by the local game wardens from game law violators contained only oat seeds and grit. Several flocks of pigeons varying in size from 10 to 40 individuals were observed consistently visiting the newly seeded oat fields in the Arcata Bottoms. It appeared that they were picking up the unburied grain from the fields and were not scratching or billing out the seeds. Field observations indicated that migrating band-tailed pigeons also fed on madrone blossoms and the early shoots of native and cultivated grasses.

COURTING

Cooing activity was first recorded on April 27 with the peak occurring during the last half of June and early July. The last record of cooing in the north coastal area was August 15. Those individuals doing the cooing early in the breeding season were usually associated with small flocks of five to seven birds. Later on in June and July the call was given typically by single individuals from a prominent perch in the nesting territory during the morning (Figure 1). It was noticed that the daily cooing activity reached its height earlier in the morning when the weather was clear than when it was foggy or cloudy.

Only one courting flight was observed during the study period. It was preceded by a lone male making four owl-like "who-hoo-hoo-hoo" calls from the top of a redwood snag. At the completion of the calls he

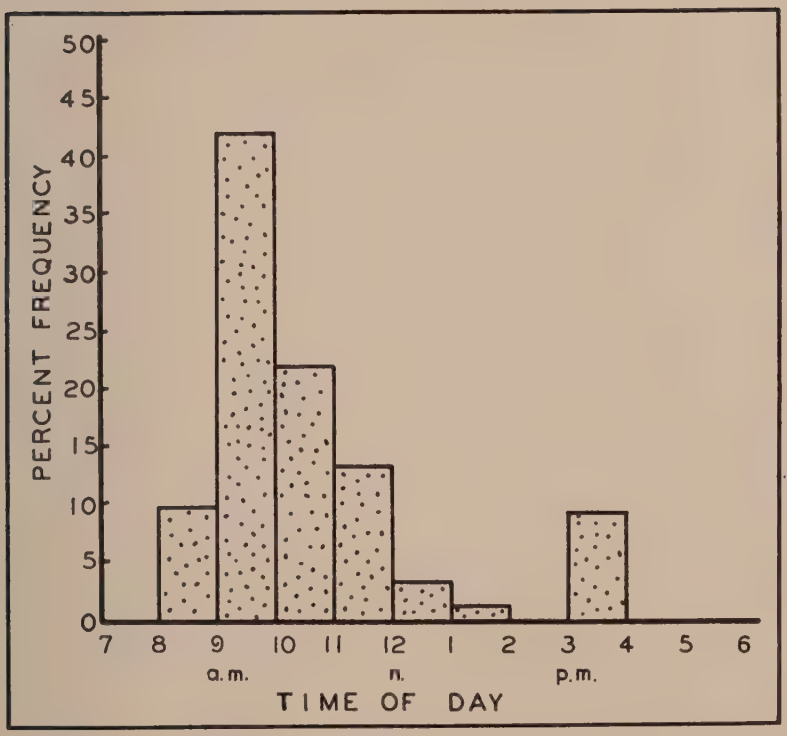

FIGURE 1. Data from 69 point observations concerning the frequency of band-tailed pigeon calls in relation to time of day.

launched himself into a slowly descending spiral flight, vibrating his wings rapidly and at the same time uttering a high-pitched rattling sound. At the termination of the spiral flight, the male landed in the top of a small alder and remained there for several minutes, later flying back to his lofty perch atop the redwood snag.

NESTING

The first nesting territory with an established pair was located on April 20 on the Arcata study area in the vicinity of the city reservoir. A series of censuses from May 1 to September 1 revealed a total of 109 individual breeding pairs in the sample study areas (Table 2). As near as could be determined from these breeding season censuses, the peak of the nesting season was from June 15 to July 15 in the north coastal area of California, 1951. Nest data reported by Davis (1938) indicated that the peak of the nesting season in the Humboldt Bay region was about June 15.

The nesting territories of 53 of these breeding pairs were found and the extent of the territorial range determined for 42. Size of the territories ranged from one-tenth of a mile radius to about one-half mile with

TABLE 2

Number of Breeding Pairs of Band-tailed Pigeons Located in Northcoastal California From April 20 to September 1, 1951

Sample study areas	Months				
	April	May	June	July	August
Hammond	0	10	15	11	7
Arcata	1	11	11	15	2
Elk River	1	1	4	17	3
Totals	2	22	30	43	12

the mean territorial radius being about one-fourth of a mile. The mean distance to the nearest known band-tailed pigeon nesting territory was 0.45 of a mile. Variability in the size of the territories seemed to depend upon the irregularity of the terrain, the abundance of the forest cover, and the proximity of a permanent water source. Nesting territories were closer in localities where water was readily available, the forest cover was dense, and the terrain was rugged or severely dissected.

A check on the activities of the breeding pairs in the nesting areas indicated that they left their territories about dawn to assemble with other nesting pigeons and to feed for approximately two hours. Then the feeding group would disperse and the birds would return to their respective territories. The path of flight was usually along some prominent watercourse. From about 8 a.m. until noon, the adults remained in the nesting areas and tended the nest or performed courting antics.

The returning parents were extremely secretive and very deceptive in their approach to the nest, dropping rapidly from a flight of returning pigeons, diving recklessly between trees and branches, and then alighting quickly among the dense cover of a tree. It was not unusual for them then to sit still for 5 or 10 minutes closely scrutinizing their surroundings. The parent that did the brooding would then drop down or walk along the branches to the nest, which was typically located on a strong, horizontal branch where it formed its first fork of lateral branches. In the meantime the other parent would silently glide from its perch and fly to a nearby prominent lookout station or feed in the vicinity.

A total of five band-tailed pigeon nests was found during the course of this investigation. Additional data were obtained from Robert Talmadge, Willow Creek, California, on three nests he had found in Humboldt County. A summarization of these data is presented in Table 3. All of the nests observed were typically fragile and amounted to little more than a crude, loose collection of twigs and forest litter to form a shallow platform. It was difficult to determine if moss had been added intentionally to some of the nests for probably many of the twigs used already had moss on their surfaces before being utilized as nest material. The following measurements were obtained: outside diameter, 7.8 inches; inside diameter, 5.0 inches; bowl depth, 1.3 inches; and thickness under the bowl, 2.1 inches.

Band-tailed pigeon eggs are pure white, smooth, glossy, and ovate. Bent (1932) reported on the measurements of a series that averaged 39.7

TABLE 3

Data Concerning the Location of Eight Band-tailed Pigeon Nests From Humboldt County, California

Nest plant species	Cover type	Cover density	Distance to habitat opening	Distance to water	Height of nest	Distance from bole
Tan oak (*Lithocarpus densiflora*)	Oak-madrone	Dense	150′	150′	7′	1′
Sitka spruce (*Picea sitchensis*)	Spruce-fir	Dense	150′	300′	15′	6′
Sitka spruce	Spruce-fir	Dense	1,200′	60′	15′	5′
Sitka spruce	Spruce-redwood	Medium	70′	30′	150′	1′
Blueblossom (*Ceanothus thyrsiflorus*)	Blueblossom-blackberry	Dense	210′	2,000′	8′	4′
Alder (*Alnus* sp.)	Alder-spruce	Dense	10′	3′	6′	3′
Alder	Alder-redwood	Dense	75′	40′	30′	4′
Alder	Alder-redwood	Dense	1,200′	30′	20′	2′

by 27.9 millimeters. Morse (1949), Neff (1947), and Grinnell, Bryant, and Storer (1918) all recorded instances of two eggs in a nest but specified that a single egg was the normal complement. Perusal of all available data on band-tailed pigeon nests in Humboldt County revealed only one egg was deposited per nest.

As pointed out by Grinnell, Bryant and Storer (1918), there is no reliable evidence that the band-tail nests more than once each year in California, except when its first nesting is disturbed. Within the confines of this study, no data were obtained to the contrary. Seven band-tailed pigeons that were killed illegally on June 13, 1951, were obtained for examination from Captain Leslie Lahr, Bureau of Patrol, California Department of Fish and Game. Four of these were females, two of which showed evidence of recent ovulation. None of the other ovarian follicles of these two females were developed larger than a number six shot (0.11 inches). The other two females contained at least five ovarian follicles larger than a number six shot and each had one follicle that was larger than a pea.

PRODUCTION

Of the five nests located in Humboldt County in 1951, one was destroyed by a construction crew falling a tree, three were successful, and the fate of one was undetermined. With the investigator's success in locating band-tailed pigeon nests being less than 5 percent of the known breeding pairs, it was deemed necessary to obtain as much data as possible on the adult : immature ratio during late summer. Field observations indicated that some young were flying by June, more were present during July, and most of the young were flying by the latter part of August. The adult : immature ratio obtained for July from observing 30 producing pairs was 2.0 to 1, while on 45 producing pairs observed in August it was 2.72 to 1. The adult : immature ratio obtained in August probably gave a better indication of the production success for the season as more of the adult birds were relieved of their nest duties and were observed with the younger birds. This data indicated that the hatching and rearing success was about 73 percent. From a post-breeding season census in late August of 123 band-tailed pigeons that were utilizing the three study areas, 26.8 percent were immatures. Morse (1949) in Oregon obtained an age sample from hunters in Marion County and reported the adult : immature ratio to be 2.78 to 1. If it can be assumed that the 109 breeding pairs had about the same production success (73 percent) as obtained from the August census, then approximately 79 young were raised to the flight stage in the study areas. Only 33 young or about 42 percent of the calculated production was observed.

COVER UTILIZATION

Spruce groves, alder thickets, and redwood snags proved to be the three most important types of cover utilized by the summer population of band-tailed pigeons in Humboldt County (Table 4). A total of 134 observations was made of 582 pigeons utilizing seven different species of trees. The value of spruce groves was actually greater than the data indicated for spruce was estimated to form less than 2 percent of the total forest cover in any of the three sample study areas. Alder was

TABLE 4

Cover Utilized by the 1951 Summer Population of Band-tailed Pigeons in Humboldt County

Tree species	Age class utilization frequency				Total observations	Number of birds observed
	20-40	40-60	60-100	100		
Redwood						
Alive	8	5	1	1	15	71
Snag	6	2	2	9	19	73
Douglas fir						
Alive	2	5	4	1	12	38
Snag	3	7	1	4	15	87
Sitka Spruce						
Alive	11	11	5	1	28	140
Snag	3	3	1	4	11	39
Alder						
Alive	23	2			25	86
Snag	2	2			4	15
Maple						
Alive	1				1	1
Snag		1			1	23
Red Cedar						
Alive	1	1			2	8
Snag						
Hemlock						
Alive		1			1	1
Snag						
Total—7 species	60	40	14	20	134	582

utilized heavily as cover probably because it was abundant along the watersheds and provided sturdy roosts. Developing spruce groves from 20 to 60 years old and alder thickets 20 to 40 years old not only were utilized for resting and roosting but they also provided acceptable nesting cover. Redwood snags provided an abundance of lofty perches that evidently appealed to the band-tails. It was believed that the live redwood trees were not as attractive as spruce or alder because the limbs drooped heavily under the birds' weight; thus it did not provide either a substantial roost or a prominent lookout post.

Factors Affecting Production and Nesting

Neff and Culbreath (1947) pointed out that population shifts other than those resulting from natural instincts seemed to be minor and local in nature. Logging operations evidently were important as one of several local factors affecting the numbers of producing band-tailed pigeons. No observations were made of migrating pigeons utilizing forest cover that was within one-half mile of logging operations or near an area that had been clear-cut within the past three years. Only one of 53 nesting territories was located in cover that had been logged within the past 10 years. All of the eight nests were more than two miles from logging activities. The one nest that was known to have been destroyed was the result of a construction crew falling trees for a new logging-mill site.

Selective logging, in which approximately 20 percent of timber was left standing, and clear-cutting in small blocks apparently did not adversely influence local band-tailed pigeon production. Limited data from two years' observations indicated that clear-cutting of timber in areas greater than one square mile seemed to cause the band-tails to abandon the area for that particular breeding season. It was believed that the lack of suitable resting, roosting, nesting, and concealment cover was responsible for this condition. Records of the cover utilized by the producing band-tails clearly showed that forest cover more than 20 years old was acceptable. The unquestionable value of uncut patches of timber was evident on the Hammond study area where 12 of 14 nesting territories were located in a stand of virgin timber about one-half mile wide and two miles long. A similar situation was present near the city reservoir on the Arcata study area where all six of the territories were located in the uncut timber left along the stream beds to protect the watershed. The combined production of these two locations was about 44 percent of the total for the three sample study areas. On the Elk River study area, 14 of 15 territories were located in second growth alder and redwood 20 to 50 years old.

It should be realized, however, that certain beneficial effects for band-tailed pigeons do occur as a result of logging operations like the increase in food producing plants in the plant succession that follows. Blackberries (*Rubus vitifolius*), salmonberries (*Rubus spectabilis*), raspberries (*Rubus leucodermis*), thimbleberries (*Rubus parviflorus*), elderberries (*Sambucus* sp.), and cascara (*Rhamnus purshiana*) are common food producing plants occurring in logged areas.

Forest fires similarly destroy suitable cover but in Humboldt County after a period of two to five years they are also followed by an abundance of food producing plants as in the areas that have been clear-cut.

As already mentioned, band-tailed pigeons utilized cover for nesting that was in close proximity to water. Only one of the eight nests under consideration was located more than 300 feet from a permanent water source and just two of the 53 territories were located more than one-half mile from permanent water. All of the other nesting territories were located less than one quarter of a mile from water. The combination of suitable, dense cover and available water seemed to meet the nesting cover requirements for no band-tailed pigeon territories were found where only one requirement was present. As pointed out by Neff (1947), pigeons usually nested in widely separated pairs. This was largely true throughout the area covered in this survey except that several pairs tended to nest in the vicinity of a permanent water supply. It was quite evident from a comparison of the nesting densities in relation to water facilities that a close relationship existed (Figure 2). The distribution map presented by Neff and Culbreath (1947) also indicated that band-tailed pigeon density and distribution was closely associated with water courses and the adjacent vegetation.

Band-tailed pigeons seemed to utilize areas for nesting that were relatively free from human interference. Not one of the eight nests was located less than about 400 yards from human habitation. All of the other territories were located at distances greater than 400 yards. Poaching and the activities of a road survey crew were believed to be responsi-

ble for the reduction of nesting from three pairs to one in an area adjacent to the city reservoir. Also there was a coincident reduction in utilization of the feeding areas in this vicinity by the band-tails following their disturbance by humans.

Logging, fire, water, and human interference were factors affecting band-tailed pigeon nesting and production that were studied. It was realized also that food was a factor but time did not permit compilation of data on this item.

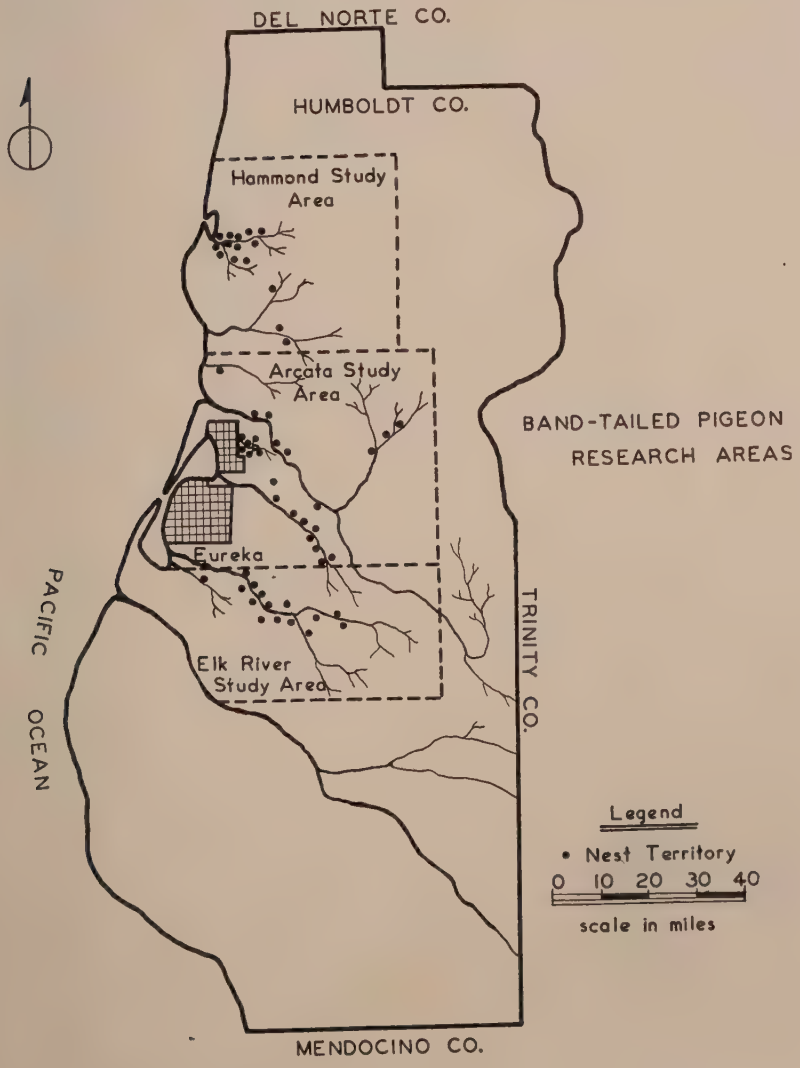

FIGURE 2. Band-tailed pigeon nesting territories in relation to available permanent water, Humboldt County, 1951.

MANAGEMENT RECOMMENDATIONS

1. The maintenance of existing cover and water facilities in the known areas of present nesting.

2. The leaving of strips of forest cover along the water courses to protect the watershed and to be utilized by the band-tailed pigeons as nesting cover.

3. The encouragement of lumber operators through common educational media and possibly through the state lumber practices code to clear-cut in small blocks because such a practice reduces soil erosion, aids tree reproduction, conserves water resources, and provides suitable production and feeding areas for the pigeons.

4. The preservation, maintenance, and/or encouragement of spruce groves because of their utilization value to the band-tailed pigeons as suitable nesting, resting, roosting, and escape cover.

5. The establishment of an annual postbreeding season census in known nesting areas or places of fall assemblage to determine the annual production as a means of better evaluating the pigeon resource.

6. The institution of trapping and banding operations to gather basic facts about distribution, kill, sex ratios, and age ratios.

7. The routine checking of hunter's bags for information concerning sex and age ratios to check on the production data. This will also give some indication of the total kill as well as the approximate number of pigeons to return to the spring breeding areas.

8. The instigation of a state-wide nesting area survey to determine those places utilized. This project should then be followed by action that would maintain these nesting areas for an assured future production.

SUMMARY

1. The peak of the band-tailed pigeon spring migration flight occurred during the last half of April.

2. Cooing activity was first recorded on April 27, 1951, with the maximum activity occurring during June and July.

3. Calls were usually given by single individuals from a prominent perch in the nesting territory during the morning.

4. Censuses from May 1st to September 1st revealed a total of 109 breeding pairs in the entire study area.

5. The peak of the nesting season was from June 15th to July 15th.

6. Variability in the size of nesting territories seemed to depend upon irregularity of terrain, abundance of forest cover, and proximity to a permanent water source.

7. The data indicated that the production success was about 73 percent with approximately 79 young being raised to the flight stage by the 109 breeding pairs.

8. Developing spruce groves from 20 to 60 years old and alder thickets 20 to 40 years old not only were utilized for resting and roosting but they also provided acceptable nesting cover.

9. Logging operations, fire, water, and human interference were factors affecting band-tailed pigeon nesting and production.

10. Management recommendations for the band-tailed pigeon in northwestern California involve habitat maintenance, postbreeding censuses, banding operations and an analysis of hunter kill data.

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AGE AND LENGTH COMPOSITION OF THE SARDINE CATCH OFF THE PACIFIC COAST OF THE UNITED STATES AND MEXICO IN 1952-53[1]

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and
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Marine Fisheries Branch, California Department of Fish and Game

This is the seventh report on the age and length composition of the catch of sardine (*Sardinops caerulea*) off the Pacific Coast of North America. Previous reports have presented data for the 1941-42 through 1951-52 seasons (Felin, et al.).

During the 1952-53 season, the fishery was carried on off California during the regular fishing season only, but off Baja California throughout the year. Through the courtesy of the processing plants at Ensenada we have sampled sardines at that port and obtained records of the tonnages landed. This enables us to include Baja California records for 1951-52 and 1952-53. The wholehearted cooperation of these processors is gratefully acknowledged.

Sardines were landed in California at Santa Cruz and Port San Luis, in the region north of Point Conception; these totaled only 44 tons, and were referred to Monterey. The San Pedro totals included fish landed at Santa Barbara, Port Hueneme, Los Angeles-Long Beach Harbor, and Newport. The 27 tons landed at San Diego were processed elsewhere, presumably in the Los Angeles-Long Beach region. There was some trucking from one port to another within California; as before, this was referred to the region of landing.

Sampling was carried on at San Pedro during the four months of the legal season. In Baja California, samples were taken throughout the year. Data presented here for Ensenada, however, cover only the six months comparable to the legal season throughout all California.

At San Pedro, as in the preceding season, five samples of 50 fish each were taken in the first half of each week and five in the last half, when available. Scales were taken from every fifth fish for a random sample. A new system of taking extra scale samples to supplement our data on the outsized fish was used this season: In each sample, scales were taken from all fish above the highest and lowest centimeter groups from which random scale samples were taken. The Ensenada sampling system was similar.

Tables 1-3 show, by sex and region of catch, the length frequency distributions of fish of each year class from the random scale samples taken in the 1952-53 season.

[1] Submitted for publication March, 1953.

Table 4 shows, by sex and region of catch, the mean length and standard error of the mean for each year class sampled in the 1952-53 season. These are based on the random scale samples only, and therefore represent the means of the frequency distributions of Tables 1-3.

Table 5 gives the calendar dates for the lunar months included in Table 7.

Tables 6-7 give the numbers of fish, by region of catch and in each year class, caught during the season. Table 6 gives the figures for the 1951-52 season in Ensenada, which have not been previously published; Table 7 the figures for both San Pedro and Ensenada for 1952-53. The number of fish caught was estimated from the total weight landed at each port in each week divided by the average weight of the fish during that period. These were summed by lunar months and ports. The apportionment of numbers of fish among the several year classes caught each lunar month was accomplished by combining the random scale samples with the extra scale samples. From the age data, the percentage of each age class within each centimeter length stratum was calculated. These percentages were then weighted according to the length frequency distributions of the 50-fish samples. The resulting percentages were used in allocating the number of fish among the different year classes.

Sampling in 1952-53 was carried on at San Pedro by Anita E. Daugherty, and at Ensenada by Harold D. Casey, Fish and Wildlife Service. Age determinations were made by the four authors. Frances N. Clark, Department of Fish and Game, and T. M. Widrig, Fish and Wildlife Service, assisted in the calculations.

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TABLE 1

Length Composition of the 1951 and 1950 Year-classes in 1952-53

Standard length mm.	1951 Year-class, age 1			1950 Year-class, age 2								
	Baja California—Ensenada			California—San Pedro			Baja California—Ensenada			Grand total		
	M	F	T	M	F	T	M	F	T	M	F	T
186	--	--	--	--	--	--	1	--	1	1	--	1
188	--	--	--	--	--	--	--	--	--	--	--	--
190	--	--	--	--	--		--	--	--	--	--	--
192	--	1	1	--	--	--	1	--	1	1	--	1
194	--	--	--	--	--	--	--	1	1	-	1	1
196	--	--	-	--	--	--	1	--	1	1	--	1
198	--	--	--	--	--	--	--	1	1	--	1	1
200	--	--	--	--	--	--	--	4	4	--	4	4
202	--	--	--	--	--	--	--	--	--	--	--	--
204	1	--	1	--	--	--	--	1	1	--	1	1
206	--	--	--	--	--	--	1	1	2	1	1	2
208	--	--	--	1	--	1	--	--	--	1	--	1
210	--	--	--	--	--	--	--	1	1	-	1	1
212	--	--	--	2	--	2	--	--	--	2	--	2
214	--	--	--	--	--	-	1	--	1	1	--	1
216	--	--	--	--	--	--	--	--	--	--	--	--
218	--	--	-	--	--	--	--	--	--	-	--	--
220	--	--	--	--	--	--	--	--	-	--	--	--
222	--	--	--	1	--	1	1	--	1	2	--	2
224	--	--	--	1	--	1	--	--	--	1	--	1
226	--	--	--	--	--	--	--	--	-	--	--	--
228	--	--	--	--	--	--	--	--	--	--	--	--
230	--	--	--	1	--	1	--	--	--	1	--	1
232	--	--	--	1	--	1	--	--	--	1	--	1
234	--	--	-	-	1	1	--	--	-	-	1	1
Totals	1	1	2	7	1	10[1]	6	9	15	13	10	23

[1] Including fish in the random samples for which length and sex are unknown.

TABLE 2

Length Composition of the 1949 and 1948 Year-classes in 1952-53

Standard length mm.	1949 Year-class, age 3									1948 Year-class, age 4								
	California—San Pedro			Baja California-Ensenada			Grand total			California—San Pedro			Baja California—Ensenada			Grand total		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
184	---	---	---	---	---	---	---	---	---	---	---	---	---	1	1	---	1	1
186	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
188	---	---	---	---	2	2	---	2	2	---	---	---	---	---	---	---	---	---
190	---	---	---	1	---	1	1	---	1	---	---	---	1	---	1	1	---	1
192	---	---	---	3	2	5	3	2	5	---	---	---	3	4	7	3	4	7
194	---	---	---	3	3	6	3	3	6	---	---	---	10	6	16	10	6	16
196	---	---	---	1	3	4	1	3	4	---	---	---	2	4	6	2	4	6
198	---	---	---	1	3	4	1	3	4	---	---	---	9	7	16	9	7	16
200	---	---	---	4	4	8	4	4	8	---	---	---	5	6	11	5	6	11
202	---	---	---	2	5	7	2	5	7	---	---	---	7	7	14	7	7	14
204	---	---	---	2	4	6	2	4	6	---	---	---	4	7	11	4	7	11
206	---	---	---	1	3	4	1	3	4	---	---	---	5	7	12	5	7	12
208	---	---	---	2	5	7	2	5	7	---	---	---	4	5	9	4	5	9
210	---	---	---	---	2	2	---	2	2	---	1	1	---	5	5	---	6	6
212	---	---	---	2	3	5	2	3	5	1	---	1	---	2	2	1	2	3
214	3	---	3	---	2	2	3	2	5	1	---	1	3	1	4	4	1	5
216	1	---	1	---	---	---	1	---	1	4	1	5	2	2	4	6	3	9
218	1	1	2	---	---	---	1	1	2	3	1	4	---	1	1	3	2	5
220	4	---	4	---	1	1	4	1	5	4	2	6	---	---	---	4	2	6

222	3	---	3	---	---	---	3	---	3	6	1	7	---	1	1	6	2	8
224	---	---	---	---	1	1	---	1	1	1	2	3	---	---	---	1	2	3
226	2	1	3	---	---	---	2	1	3	4	2	6	---	---	---	4	2	6
228	2	1	3	---	---	---	2	1	3	11	2	13	---	---	---	11	2	13
230	3	2	5	---	---	---	3	2	5	11	6	17	---	---	---	11	6	17
232	2	1	3	---	---	---	2	1	3	7	4	11	---	---	---	7	4	11
234	2	2	4	---	---	---	2	2	4	9	5	14	---	---	---	9	5	14
236	---	1	1	---	---	---	---	1	1	9	4	13	---	---	---	9	4	13
238	1	1	2	---	---	---	1	1	2	12	12	24	---	---	---	12	12	24
240	2	---	2	---	---	---	2	---	2	5	6	11	---	---	---	5	6	11
242	1	2	3	---	---	---	1	2	3	4	5	9	---	---	---	4	5	9
244	---	---	---	---	---	---	---	---	---	---	10	10	---	---	---	---	10	10
246	---	1	1	---	---	---	---	1	1	2	4	6	---	---	---	2	4	6
248	---	---	---	---	---	---	---	---	---	---	6	6	---	---	---	---	6	6
250	---	1	1	---	---	---	---	1	1	---	---	---	---	---	---	---	---	---
252	---	---	---	---	---	---	---	---	---	1	1	2	---	---	---	1	1	2
254	---	---	---	---	---	---	---	---	---	---	1	1	---	---	---	---	1	1
256	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
258	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
260	---	---	---	---	---	---	---	---	---	1	---	1	---	---	---	1	---	1
Totals	27	14	43[1]	22	43	65	49	57	106	96	76	177[1]	55	66	121	151	142	293

[1] Including fish in the random samples for which length and sex are unknown.

TABLE 3

Length Composition of the 1947, 1946 and 1945 Year-classes in 1952-53

Standard length mm.	1947 Year-class, age 5									1946 Year-class, age 6									1945 Year-class, age 7		
	California—San Pedro			Baja California—Ensenada			Grand total			California—San Pedro			Baja California—Ensenada			Grand total			California—San Pedro		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
190	--	--	--	1	--	1	1	--	1	--	--	--	--	--	--	--	--	--	--	--	--
192	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
194	--	--	--	3	1	4	3	1	4	--	--	--	--	--	--	--	--	--	--	--	--
196	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
198	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
200	--	--	--	1	--	1	1	--	1	--	--	--	--	--	--	--	--	--	--	--	--
202	--	--	--	1	--	1	1	--	1	--	--	--	--	--	--	--	--	--	--	--	--
204	--	--	--	3	--	3	3	--	3	--	--	--	--	1	1	--	1	1	--	--	--
206	--	--	--	1	--	1	1	--	1	--	--	--	--	--	--	--	--	--	--	--	--
208	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
210	--	--	--	1	1	2	1	1	2	--	--	--	--	1	1	--	1	1	--	--	--
212	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
214	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
216	--	--	--	--	1	1	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--
218	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
220	2	--	2	--	--	--	2	--	2	1	--	1	--	--	--	1	--	1	--	--	--
222	3	--	3	--	--	--	3	--	3	--	--	--	--	--	--	--	--	--	--	--	--
224	3	3	6	--	--	--	3	3	6	--	--	--	1	--	1	1	--	1	--	--	--

226	7	4	11	--	--	--	7	4	11	1	1	2	--	--	--	1	1	2	--	--	--
228	2	4	6	--	--	--	2	4	6	3	1	4	--		--	3	1	4	--	--	--
230	6	2	8	--	--	--	6	2	8	1	--	1	--	-	--	1	--	1	--	--	--
232	2	1	3	--	--	--	2	1	3	1	3	4	--	--	--	1	3	4	2	--	2
234	5	5	10	--	--	--	5	5	10	3	1	4	--	--	--	3	1	4	1	--	1
236	8	4	12	--	--	--	8	4	12	4	1	5	--	-	--	4	1	5	--	--	--
238	8	11	19	--	--	--	8	11	19	1	--	1	--	-	--	1	--	1	--	--	--
240	3	4	7	--	--	--	3	4	7	1	2	3	--	--	--	1	2	3	--	--	--
242	2	4	6	--	--	--	2	4	6	--	3	3	--	--	--	--	3	3	1	--	1
244	4	5	9	--	--	--	4	5	9	1	6	7	--	--	--	1	6	7	--	--	--
246	4	2	6	--	--	--	4	2	6	--	1	1	--	--	--	--	1	1	--	--	--
248	3	2	5	--	--	--	3	2	5	1	2	3	--	--	--	1	2	3	--	1	1
250	1	3	4	--	--	--	1	3	4	2	--	2	--	--	--	2	--	2	--	-	--
252	--	1	1	--	--	--	--	1	1	--	1	1	--	--	--	--	1	1	--	--	-
254	--	1	1	--	--	--	--	1	1	--	1	1	--	--	--	--	1	1	--	--	--
256	1	--	1	--	--	--	1	--	1	--	--	--	--	--	--	--	--	--	--	--	--
258	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	-	--	--	--
260	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
262	--	1	1	--	--	--	--	1	1	--	--	--	--	--	--	--	--	--	--	-	--
264	--	1	1	--	--	--	--	1	1	--	--	--	--	--	--	--	--	--	--	--	--
Totals	64	58	131[1]	11	3	14	75	61	136	20	23	44[1]	1	2	3	21	25	46	4	1	5

[1] Including fish in the random samples for which length and sex are unknown.

TABLE 4

Number of Fish, Mean Length, and Standard Error of the Mean for Each Year-class in the 1952-53 Season by Region of Catch

Year-Class	Baja California—Ensenada			California—San Pedro		
	No.	M.	S.E.	No.	M.	S.E.
1951						
Male	1	—	—	—	—	—
Female	1	—	—	—	—	—
Totals	2	—	—	—	—	—
1950						
Male	6	203	5.64	7	220	4.72
Female	9	201	1.58	1	—	—
Totals	15	202	2.32	8	222	4.58
1949						
Male	22	200	1.40	27	226	1.90
Female	43	203	1.22	14	235	3.42
Totals	65	202	0.94	41	229	1.62
1948						
Male	55	201	0.88	96	231	0.92
Female	66	203	0.90	76	237	1.12
Totals	121	202	0.64	172	234	0.72
1947						
Male	11	200	1.88	64	235	1.18
Female	3	207	7.12	58	238	1.36
Totals	14	202	2.04	122	237	0.84
1946						
Male	1	—	—	20	235	2.56
Female	2	—	—	23	241	2.38
Totals	3	211	8.04	43	238	1.52
1945						
Male	—	—	—	4	235	10.38
Female	—	—	—	1	—	—
Totals	—	—	—	5	238	9.00

TABLE 5

Calendar Dates of Lunar Months for the 1952-53 Season

"July"	July 7-August 5
"August"	August 6-September 3
"September"	September 4-October 3
"October"	October 4-November 2
"November"	November 3-December 1
"December"	December 2-December 31
"January"	January 1-January 29

TABLE 6

Age (Year-class) Composition of the Sardine Catch in the 1951-52 Season (Numbers of fish are given in thousands, i.e., 000 omitted)

	Catch		Number of fish by age (year-class)				
	Tons	Number	1	2	3	4	5
			1950	1949	1948	1947	1946
Ensenada[1]							
"August"	3,024	27,436	-------	-------	27,436	-------	-------
"September"	2,969	28,651	-------	5,730	22,921	-------	-------
"October"	1,180	12,162	-------	2,432	9,730	-------	-------
"November"	462	4,493	674	899	2,920	-------	-------
"December"	577	5,309	1,062	1,239	2,477	531	-------
"January"	655	6,026	194	681	4,568	486	97
Totals, Ensenada	8,867[2]	84,077	1,930	10,981	70,052	1,017	97

[1] Data on year-class composition of the catch at Ensenada now are available for a part of 1951-52, comparable to the California fishing season. For the remainder of the fishing year 1951-52 (June 1 through May 31) the landings amounted to 6,245 tons. Almost half of this tonnage was taken in the "July" lunar month just prior to the time sampling in this region was started.

[2] In addition 1,089 tons were landed that are not included in this total.

TABLE 7

Age (Year-class) Composition of the Sardine Catch in the 1952-53 Season (Numbers of fish are given in thousands, i.e., 000 omitted)

	Catch		Number of fish by age (year-class)						
	Tons	Number	1	2	3	4	5	6	7
			1951	1950	1949	1948	1947	1946	1945
Monterey									
"September"	44	231[1]	-------	5	38	97	71	15	5
San Pedro									
"October"	2,252	11,741	-------	235	1,917	4,951	3,601	783	254
"November"	1,033	5,276	-------	70	443	2,448	1,484	753	78
"December"	719	3,821	-------	77	246	1,817	1,163	518	-------
"January"	445	2,355	-------	38	188	725	1,102	302	-------
Totals San Pedro	4,449	23,193	-------	420	2,794	9,941	7,350	2,356	332
San Diego	27	143[1]	-------	3	20	62	44	12	2
Totals California	4,520	23,567	-------	428	2,852	10,100	7,465	2,383	339
Ensenada									
"July"	432	3,238	-------	-------	1,363	1,875	-------	-------	-------
"August"	817	5,688	68	548	1,919	2,673	343	137	-------
"September"	1,342	9,543	-------	658	3,291	5,594	-------	-------	-------
"October"	640	4,576	-------	158	1,262	2,683	473	-------	-------
"November"	2,011	19,928	664	1,329	5,314	12,621	-------	-------	-------
"December"	1,459	10,848	-------	723	1,085	6,508	2,170	362	-------
Totals Baja California	6,701[2]	53,821	732	3,416	14,234	31,954	2,986	499	-------
Grand totals	11,221	77,388	732	3,844	17,086	42,054	10,451	2,882	339

[1] Numbers of fish in the Monterey catch were prorated at the same ratio of age composition as the San Pedro catch for October and in the San Diego catch as the San Pedro catch for October and December. San Diego deliveries were all made in these two months.

[2] At Ensenada some fishing was carried on throughout the calendar year. For 1952 the total landings amounted to 9,625 tons.

REVIEWS

An Angler's Anthology

Edited by Eugene Burns; The Stackpole Company, Harrisburg, Pennsylvania, 1952; 147 p.; $5

Writing a book like this would be a lot of fun. Mr. Burns has gathered an amazing array of selections concerning fish and fishing, that range from an excerpt from the Gospel According to St. John to a selection from his own "Advanced Fly Fishing" published in 1952. Other pieces are gathered from such unlikely sources as Browning's "Pippa Passes," Byron's "Don Juan," and Milton's "Paradise Lost." The anthology has a total of 146 selections from 92 authors including Aelfric's "Colloquy No. 5" (circa 1000 AD), which is believed to be the first article written in English about fishing.

An Angler's Anthology is not one of the usual collections of semi-fictionalized histories of personal fishing prowess nor is it a meticulous account of how to cast a plug or fly. It is, instead, a series of quiet sketches, many of which will be of interest only to the true angler and not to the over-equipped, carefully mechanized horde who have forgotten that sports angling is for pleasure.

I agree with the author when he says that there is a real need for a return to the quietness and tranquillity of the stream, and I believe he has achieved that in some measure with this volume. It is unfortunate that its cost should be so high.—*J. B. Kimsey, California Department of Fish and Game.*

New Handbook of Freshwater Fishing

By Lee Wulff; J. B. Lippincott Company, Philadelphia and New York, 1951; xiv + 242 p.; $2.95. Illustrated by the author.

Book reviewing is a sort of game. Games have rules. And one of them forbids peeking at the publisher's review on the dust jacket before your own review has been written. I first prepared this account following these rules. But to my consternation I found that the first reviewer must have been looking over my shoulder. He had borrowed my thoughts and even some of my phrases. I can do nothing but reiterate them.

This is a revision of the edition published in 1939. The general field of fresh-water fishing is well covered: fly fishing, bait casting, spinning, still fishing, trolling. There is a chapter on the quarry: trout, salmon, bass, bluegills . . . even bullheads and eels. Lures, natural baits, hooks, knots, and the choice of gear receive attention. These are standard subjects for a fishing handbook—which is as it should be. A handbook should strive to be comprehensive rather than startling.

Wulff is comprehensive and succinct. He has prepared a compact, meaty, little volume. It is a straightforward, how-to-do-it book without idle musings or wasted words, and containing a minimum of personal reminiscence. The beginner gets a good appraisal of the field and he can look elsewhere for amplification. The more advanced angler will find a good review of fundamentals and a few tips to which not much attention is given in other books. For example, there is a sketch of the best knot used to tie thread tippets to gut.

Wulff closes with this paragraph: "Game fish are worth far more than their food value. The actual cost of putting a pound of live game fish into our waters is amazingly high. Other fish that do not furnish sport on rod and reel are just as fine table fare but their taking doesn't deprive another angler of the bright moment of sport a game fish will give him if it is returned to the stream again after its capture. The fish you release is your gift to another angler and, remember, it may have been someone's similar gift to you."—*Wm. A. Dill, California Department of Fish and Game.*

Fly Fishing for Trout

By Richard Salmon; Greenberg, New York, 1952; xiii + 240 p.; $3.50. Illustrated by the author.

This new book has sections on the species of trout: their senses; tackle; casting; dry-fly, wet-fly, nymph and streamer fishing; fly tying; entomology, etc. Thus, in general organization, it differs little from a score of other fishing books.

But it also has certain differences which demand attention. First, it has a most attractive jacket, a color photograph of a Fanwing Royal Coachman on a bright blue background. Second, there is a good deal of information on recent developments such as the use of Platyl and Dermalon sutures for leaders. Third, the descriptions and accompanying illustrations of fly tying are excellent. Fourth, Salmon presents a check list of fishing equipment which certainly outdoes any other check list which I have seen. And fifth, his recipes for cooking trout will deter even the most ardent conservationist from returning all his fish to the stream.

The customary references to Izaak Walton, Theodore Gordon, Halford et al., are here. Furthermore, the text is liberally sprinkled with allusions to such oddly assorted company—for a fishing book as: Uncle Remus, Diamond Jim Brady, Charles Darwin, Caspar Milquetoast, Cezanne, Lot's wife and William Blake.

All in all, this is a pleasant little book, well illustrated, and written by a perfectionist with a sense of humor.—*Wm. A. Dill, California Department of Fish and Game.*

The Sage Grouse in Wyoming

By Robert L. Patterson; Wyoming Game and Fish Comm. and Sage Books, Inc., Denver, Colo., 1952; 341 p. + 96 full page photographs. $5.

This work represents a complete study of the sage grouse and will be a wonderful reference book for workers studying and managing the bird or to people just interested in game birds or ornithology. Upon reading this book one can easily see why Dr. Patterson will be considered the foremost authority on the sage grouse.

The book is based on the author's four-year study which commenced when he took over the leadership of Wyoming's Sage Grouse Pittman-Robertson Project in 1948. His work is supplemented by past information from the project's quarterly reports and frequent references to findings of other workers. The photographs taken by Dr. Patterson are excellent and visually portray subject matter which is practically impossible to describe. They also represent patience and skill which anyone will recognize who has attempted taking pictures of wildlife in the field.

The book is divided into four main parts. Part I deals with the sage grouse and its environment, the first part of which is concerned with the bird all through the West. It covers such subjects as taxonomy, range, distribution, abundance, historical accounts, etc. Particularly informing are the subjects on previous studies and current investigations which bring the reader abreast to present times. The second section of Part I takes up the findings of the study on the environmental relationships of the sage grouse to its habitat.

Part II is concerned with the natural history of the sage grouse populations. Inventory and census methods and the life history are covered in this section. The work on the life history was especially well done in a very complete and thorough manner. Observations that were unsatisfactorily explained by other workers are plausibly explained by the author through his intimate knowledge of the bird. His pictures of courtship and mating are excellent and on this subject alone he presents 24 full page photographs.

Association with man is the topic of Part III. Trapping and transplanting in Wyoming, hunting seasons in Wyoming and populations in regard to land utilization are the subjects covered. The part on trapping gives the history, equipment, methods, handling, location of traps, and evaluation of the whole program. That on the hunting seasons tells the nature of seasons, determination of the kill, aging and sexing, hunter success, hunting pressure and relation of growth and development to hunting season dates. In Part IV, restoration and management complete the well rounded book.

The book contains 18 figures, 54 tables, as well as 96 full page photographs. There are five pages of references which represent the majority written about this relatively little-studied bird.

It is felt that this book will rank with such classics as "The Ring-Necked Pheasant and Its Management in North America," "The Ruffed Grouse and Its Management," and the recent "Elk of North America."—*Jack L. Hiehle, Department of Fish and Game.*

Salt Water Fishing

By Van Campen Heilner; Alfred A. Knopf, Inc., New York, 1953; 328 p., 13 color plates, 96 pages of photographs. $7.50.

This second edition of "Salt Water Fishing," revised and enlarged, with new illustrations, is one of the famous Borzoi books for sportsmen.

Van Campen Heilner has a rare combination of abilities as fisherman, trained ichthyologist, and writer. He has arranged his book in similarly organized chapters, each devoted to a species of fish or a group of fishes that are treated alike in fishing. For instance, the first chapter is concerned with the Atlantic Coast weakfish and contains a series of fascinating tales of fishing for them. The author gives the reader the benefit of his long and varied experience by describing both the tackle to be used for each species and his favorite grounds for fishing. There is also a discussion of bait, boats, weather and tides, and of how to hook, play and land each type of fish. If a fisherman is interested in the history of the record fish of each type, this is also to be found.

The two outstanding additions to the new edition are a full discussion of The International Game Fish Association and an expansion of the chapter devoted to the tuna. The author has refrained from mentioning the additional pressure on our game fish from the greatly increased numbers of anglers throughout the United States, but a very subtle concession is made when he states that a celebration is in order when a 40-pound striped bass is taken. In the first edition the celebration was called for only when a 45-pounder was landed.

It is unfortunate that Mr. Heilner could not adequately cover sport fishing on the west coast. Nevertheless, this fact will not detract from the Westerner's enjoyment of the book. And if he ever has the opportunity to fish on the east coast, his investment will be returned many times over. *–Parke H. Young, California Department of Fish and Game.*

Bob White

By R. W. Eschmeyer; Fisherman Press Inc., Oxford, Ohio, 1952; 50 p. illus., $0.50 (paper); $1.50 (cloth).

This book is the latest of a series of children's books on game and fish. Other books in this series by Dr. Eschmeyer are: Billy Bass, Tommy Trout, Freddy Fox Squirrel, Bobby Bluegill, and Charley Cottontail.

These books are entertaining, well written stories in which authentic life history and management information is presented in a story form that will be read and enjoyed by children. This is conservation education at an early age where the long term benefits will probably be much greater than a great number of articles written for older audiences.—*Wallace G. Macgregor, California Department of Fish and Game.*

Spearfishing

By I. S. Ivanovic; A. S. Barnes and Company, New York, 1953; 79 p. Illustrated.

"Spearfishing" is a book for the novice and gives the basic information of interest to a rank beginner. It will be of help to those who have no knowledge of the wide variety of conditions that can be encountered; for instance, a chapter is devoted to choosing the fishing (spearfishing) site. There is also some discussion of the equipment that a prospective diver would need plus advice in the technique of spearfishing.

The author writes from his experience in the Mediterranean; however, the information contained in the book will apply in California just about as well as it would there. Mr. Ivanovic gives some advice about photographing the catch of the spearfisherman—advice which might impress one as being a little on the whimsical side. He firmly suggests that a fish should be photographed in the hands of a child whose arms are outstretched to the camera. This has the effect of making the fish appear relatively larger than it actually is. This suggestion is amply defended in the first paragraph of Chapter I, where the following appears: "Men of the highest integrity lie about fishing. If you lie about your fishing experiences you are, indeed, damaging your own immortal soul, but you are doing very little harm to anyone else."

One rather glaring error appears in the caption of a photograph on page 37. The fish called a baby manta ray is not a manta but a member of family Rhinobatidae, which includes California's common shovelnose guitarfish. A baby manta will resemble its parents.

A beginner in the sport of spearfishing will find this little volume adequate to provide the information he will need. That is the intention of the book; that is what it will do.—*Parke H. Young, California Department of Fish and Game.*

Natural Salt Water Fishing Baits

By Vlad Evanoff; A. S. Barnes and Company, New York, 1953; 96 p. $1.75.

This book describes briefly but quite adequately the more important bait species, from worms to fishes, which can be used as salt water baits and the methods of obtaining and using them. It is complete with good line drawings to aid in identification.

The angler, no matter where in the United States he lives, will find the most suitable baits for use in his area described herein. If the angler is interested in obtaining and keeping his own bait supply he will find the pertinent information regarding capture and preservation well covered. Also included in some detail are the methods of rigging the different types of bait for catching various kinds of fish.

This book should prove helpful and informative to the beginning and experienced fisherman alike.—*John L. Baxter, California Department of Fish and Game.*

Fun With Trout

By Fred Everett; the Stackpole Co., Harrisburg, Pa., 1952; 287 p.; illustrated; $7.50.

The foreword says: "This book has been designed . . . to present the whole rounded picture of trout fishing through a series of paint, line and word sketches as an angling artist-author sees it, to the end that all who study the picture might learn how to have more fun with trout." It is doubtful if most people desire as rounded a picture as Fred Everett has presented. Parts of the book are reprinted from earlier magazine articles; these should have been abridged. However, each reader can find what he wants: chapters on wet-flying, dry-flying, fly-tying; on trout and their habits and foods; on conservation; love of nature; and fairness to one's fellow man.

"Fun With Trout" is highly personalized. It is written by an imaginative angler, a nonconformist who is impatient of unproved theories.

Although this is not a "how-to-do-it" book, it is full of useful tackle tips, including simple ways to identify tippets, how to glue felt on waders, etc.

Fred Everett is as well known as an artist as he is as a writer and angler. His book contains four colored plates, 15 full-page, black-and-white sketches and innumerable headings and marginal illustrations. Its sumptuous appearance puts it in the "gift book" class. There are two introductions, one by Charles K. Fox and one by Ray Bergman. The first is of real interest in its description of the evolution of fly-fishing in both England and America.

The author, who is a Senior Editor in the New York State Conservation Department, has some interesting suggestions for trout fishing regulations: virtually no closed season; no size limits; no creel limits and fewer laws. Obviously, he stresses the release of trout. He has a good concept of watershed management and presents an excellent description of what a state can do to develop an intelligent conservation program.

Everett's angling philosophy can be summed up in these words: "The day of catching trout just for the frying pan is over; the time has come to enjoy it as a beloved sport, a sport played as all sports should be played, for relaxation and the fun of it. Whoever accepts that fact can really have fun with trout."—*Wm. A. Dill, California Department of Fish and Game.*

Water

By Thomson King; The MacMillan Company, New York, 1953; 234 p.; $3.50.

Daily water use throughout the United States averages more than 100 gallons per person. As a nation, following our usual thoughtless pattern, we do practically nothing for water conservation, although we are extremely capable of contributing to the destruction of our water sources. "Water" is basically concerned with conservation, but it is written in a style that avoids the pointed lessons of many conservation books. The reader of "Water" will be reminded of his school days when he learned of some of the chemical and physical properties of this substance. Beyond that, he will encounter page after page of amazing information that pertains to

practically nothing else. If one has little considered the importance of water in our everyday lives, he will be surprised to learn that water prepared the earth for life in the beginning. The reader should be moved toward conservation from admiration of the qualities of water alone. A small section of the book is devoted to a discussion of this problem. As a nontechnical work, "Water" should take its place among the more important books devoted to conservation. It should also be a welcome addition to the library of those who prefer awesome fact to plain fiction.—*Parke H. Young, California Department of Fish and Game.*

REPORTS

FISH AND GAME CASES

January, February, March, 1953

Deer violations	107
Waterfowl violations	225
Upland bird violations	87
Inland fishing violations	210
Ocean sport fishing violations	160
Commercial fishing violations	37
Violations for having loaded gun in a car	215
Violations for trespass on cooperative areas	53
Violations for angling without a license	326
Violations for hunting without a license	59
Miscellaneous	193
Totals	1,672

FINES IMPOSED

January, 1953	$18,570
February, 1953	18,490
March, 1953	20,400
	$57,460

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